Low Cost Portable Digital Oscilloscope

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***Abstract*— An oscilloscope is basically a graph displaying device- it shows the graph of an electrical signal, be it input or output or both, depending on the number of channels. It shows how the signal changes over time. It can be used to find various signal parameters like frequency; noise etc. despite its usefulness, its presence is limited only to laboratories, due to its high cost and bulky nature. As a solution to this problem, we are designing a low cost, portable oscilloscope catering to students. The bulky CRT display will be replaced by a laptop screen. The use of basic components like opamps, capacitors, resistors and a cheap PIC microcontroller makes the design cost effective. A software application will display the output on a MATLAB based GUI. Our oscilloscope will include all the features of a traditional oscilloscope while being more flexible.**

***Index Terms*—: dsPIC30F2020, FT232R, GUI, Programmable Gain Amplifier (PGA)**

I. INTRODUCTION

The traditional oscilloscopes found in laboratories are unaffordable for students and hobbyists and their bulky nature limits their portability. The goal of our project is to design a low cost, portable oscilloscope that is viable for students and researchers. The highlights of this oscilloscope are:

- Costs less than Rs 2000
- Captures frequencies up to 50khz
- Supports 2 channels simultaneously
- Portable

To make it portable, the oscilloscope will be connected to a laptop via the USB por0074. The bulky CRT will be replaced by the laptop screen. The device will be powered via the USB port, which eliminates the need for an external power supply.
The prototype will consist of a two-channel instrument. This allows the user to compare two signals together. The bandwidth of the device will cover frequencies up to 50khz. This range is sufficient for audio, servo and biomedical signals. All these features will be incorporated with the help of a powerful microcontroller (dsPIC30F2020) containing a 10-bit ADC. Few basic components like resistors, operational amplifiers, capacitors and a programmable gain amplifier make up the analog front end through which the input signal is given. All this will make the design highly flexible and cost efficient.

II. PROPOSED IDEA

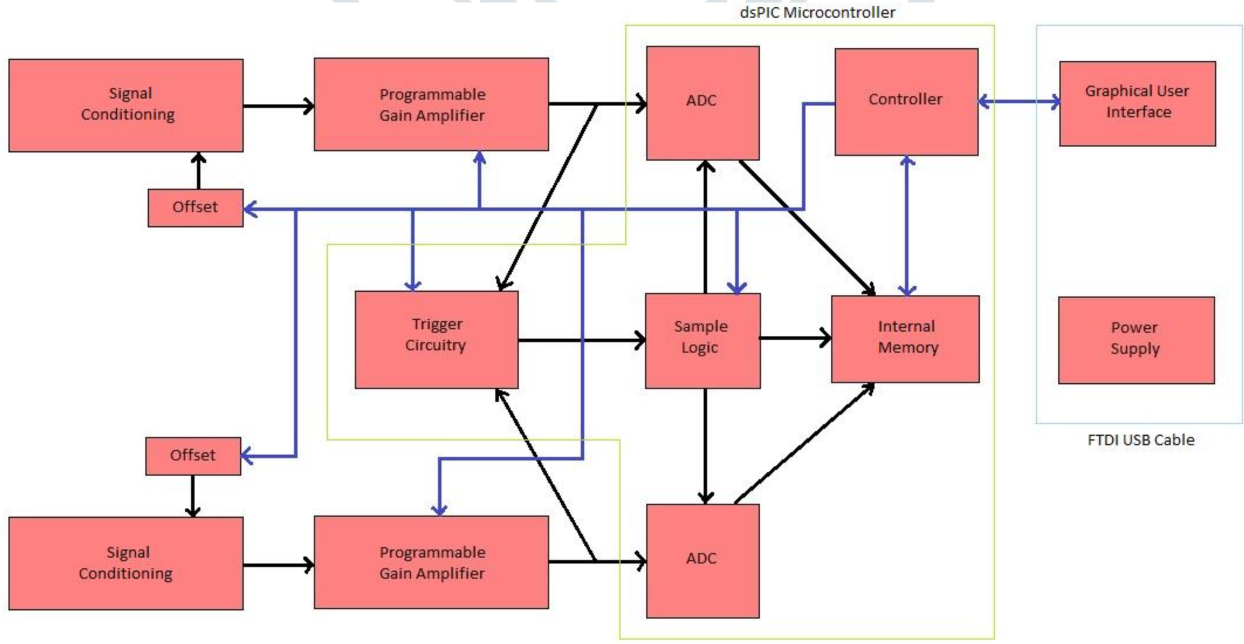

Fig.1 Block Diagram

III. PROJECT ARCHITECTURE

Input Stage : The input stage will consist of the analog front end which does the job of conditioning the input signal. The input signals will be applied to this analog circuit which conditions them. The microcontroller's ADC has a maximum voltage range of 0-5v. Input signals out of this range can damage the microcontroller. So depending on the signal level, the analog circuit will either attenuate it or amplify it to make it suitable for the microcontroller. The circuit will consist of resistors, capacitors, diodes, op-amps and programmable gain amplifiers.

Intermediate Stage : The microcontroller dsPIC30F2020 will form the intermediate stage of the oscilloscope. It is a 16-bit microchip PIC with many desirable features. It has a high operating speed and runs 32 MIPS on a 128 Mhz clock. It is available in a user friendly DIP package. It has an analog-to-digital convertor which acquires samples at 2Msamples/sec. It can acquire 2 channels simultaneously at 1Msample/sec. Samples acquired will be saved in the microcontroller and later on sent to the laptop via serial communication. A set of comparators present inside the microcontroller will be used to implement a full scope trigger and selectable edge polarity, which reduces the component count and cost by a large extent. The dsPIC supports SPI and USART communication, which it will use to control the analog frontend as per the commands sent from the user interface on the laptop

Output Stage : The laptop will be at the output end. The MATLAB based GUI will be used to display the changes the signal undergoes over time due to operations performed on it. The connection to the laptop will be very simple. The oscilloscope will use a USB to serial convertor cable from FTDI. This cable has an inbuilt FT232R chip which translates the USB data stream into an asynchronous serial data stream. This way the oscilloscope can send and receive data as though on a simple RS232 link.

Proposed Graphical user Interface (GUI) :

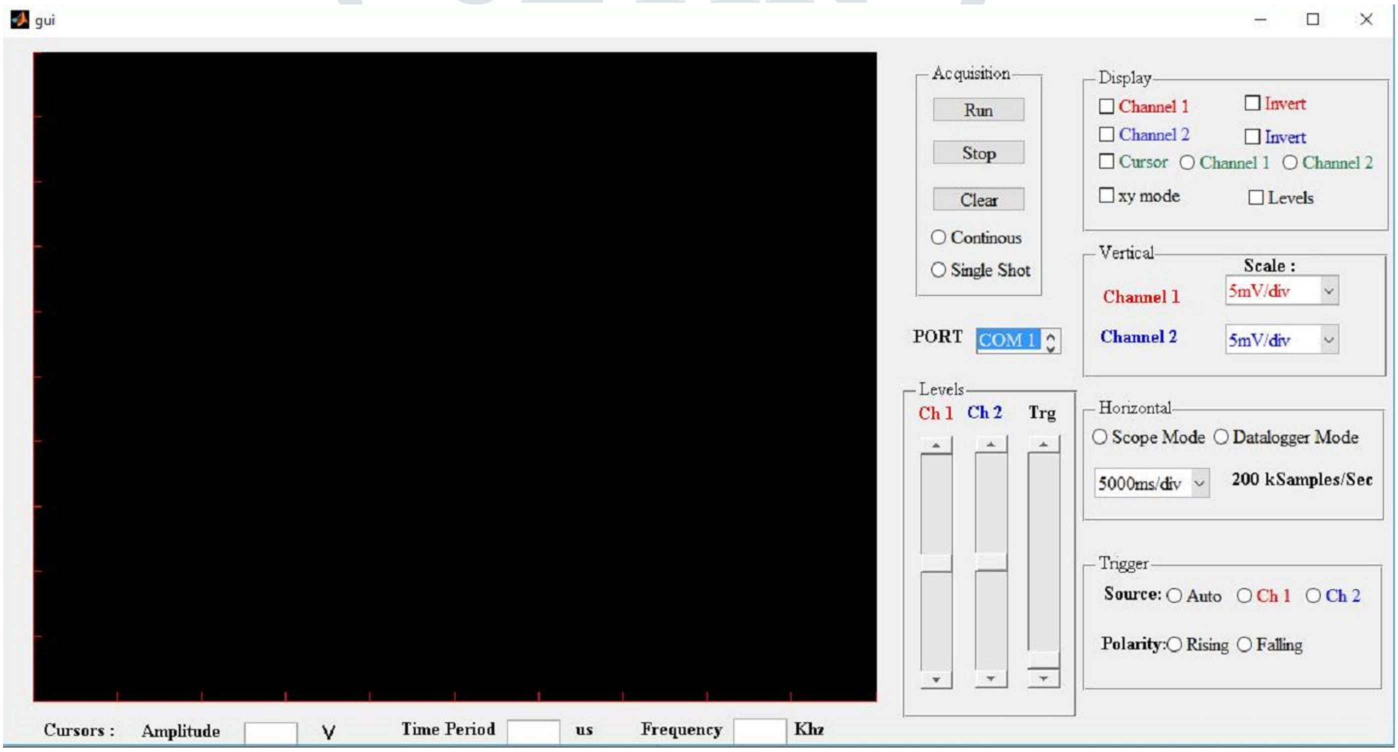

Fig.2 GUI

GUI Functions:

The black screen is used to display the signal being measured. The various controls provided in the proposed prototype are:

- ACQUISITION: This provides the main control of acquisition process.
- DISPLAY : Determines how the acquired data is to be displayed.
- VERTICAL : Controls the input amplification/attenuation for each of the two input channels.
- LEVELS : Sets the voltage offset for each channel, and the trigger threshold level.
- HORIZONTAL: Controls the sampling speed, delay, and sampling method. Datalogger mode can be used to record slowly varying signals.
- TRIGGER : Defines the trigger source.

On the bottom there is a status bar that displays the cursor information which can used to make measurements on the displayed waveforms (e.g. to determine the signal amplitude or frequency). This eliminates the need of manually calculating the readings using volt/div knob and X-Y axis.

IV. Working

The input signal will be applied to the signal conditioning circuit, where it is attenuated by a factor of 5. This will increase the maximum voltage range up to 25v. To measure a negative voltage, a programmable offset will be provide by the microcontroller. Hence the oscilloscope can display signals from -12.5v to +12.5v.

The obtained conditioned signal will be given to Programmable gain amplifier (PGA). The PGA will be used to change the channel gain and can provide a gain of 1, 2, 5 and 10. The PIC will control the PGA through a standard SPI interface with three signal lines- clock, data and chip select. The chip select pin is used to select the channel whose gain is to be varied. The output of the PGA will go to the ADC inside the PIC. A second input is given to the comparator inside the PIC. The comparator generates an interrupt whenever the input voltage crosses a particular threshold value in a predefined direction.

The ADC will convert the analog signal into digital numbers. The sample logic will control the sampling of the digital signal and the converted data will be stored in the internal memory of the microcontroller. The trigger circuitry decides when to sample. The controller will decide the signal gains, the offset to be added, selecting the trigger source, setting up the sample logic and communicating with the laptop. USB to PC interface will be provided by the FTDI232R serial- to USB convertor cable that translates the USB data stream to a simple RS232 asynchronous serial data stream, which makes the transmission and reception of data very convenient. The desired output will be displayed on the laptop screen using a MATLAB based GUI.

V. Advantages Over Traditional Oscilloscopes

1) Low cost (less than Rs 2000), while traditional oscilloscopes cost around 40k
2) Portable
3) Software upgradeable
4) The obtained waveform can be stored, shared and used for signal processing
5) The oscilloscope can also be converted into a spectrum analyzer

VI. Conclusion

In today's rapidly developing world, where the birthplace of inventions has become our very own home, we come across stories of students building and developing new things in various fields. But when it comes to the field of electronics and telecom, testing of any circuit requires the use of a CRO/DSO which is restricted to the laboratories. Cost and portability restricts the availability of this instrument in our homes. Our oscilloscope design can overcome these barriers and pave way for hobbyists to test circuits at home. Students can practice experiments, build new circuits and test them and also use the stored data elsewhere by means of our oscilloscope, in the convenience of their homes. Our design is affordable, flexible and handy.

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