Low-Cost Audio Storage Oscilloscope With RTC, GPS and Wi-Fi for Lab-at-home Applications

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Introduction

- Goal of this project is to design and develop a low cost, easy to build, battery operated digital storage oscilloscope that is capable of operating at audio frequencies (10Hz - 20kHz) and has RTC, Wi-Fi and GPS capabilities.

- Final product will allow user to sample and display the signal, stamp it with metadata containing location and time information and send it over Wi-Fi to a remote location. By having these features, the device can be used in remote education by allowing teacher to observe measurements of individual students or can be used as a data logger equipment that works on a battery.

Specifications and Design Requirements

- The DSO should be low cost to be accessible to the students and hobbyists without removing too much functionality.
- It should have at least 20 kHz bandwidth to be usable in lab experiments. And its maximum input voltage limit must not be too low.
- It should be battery powered to be portable and convenient. And a removable battery is good for when extra use time is needed. When user want to power it with direct power source it must be able to use that source instead of the battery.
- It should be able to send waveform to a distant place to view it later or share it with others.
- It should have enough memory to display the measured signal during meaningful time.

Solution Methodology

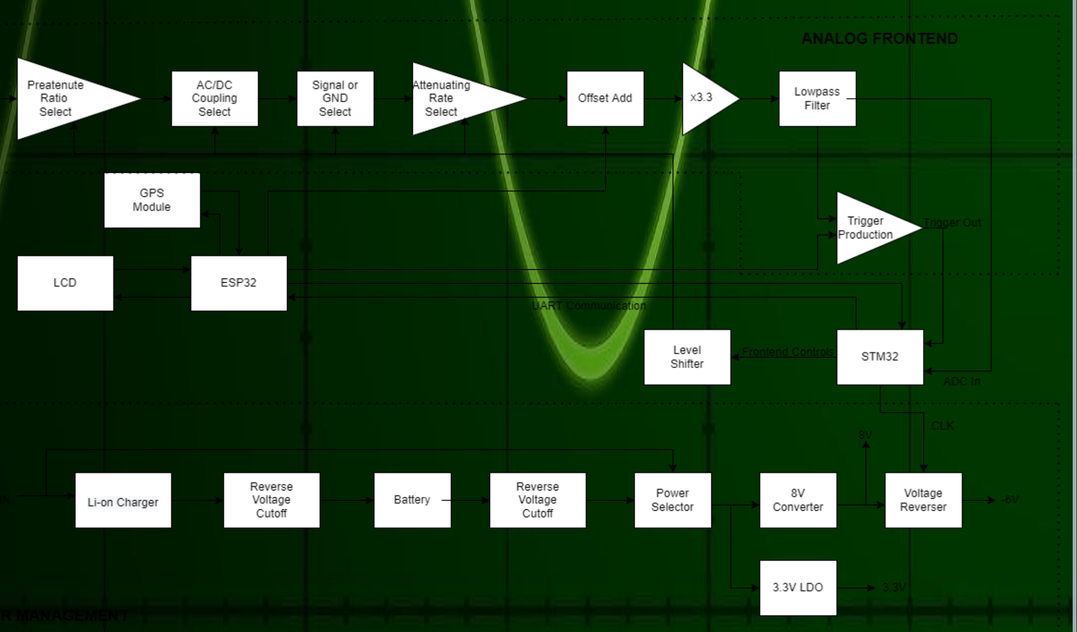

Figure 1

- To produce a low cost yet useful enough and easy to build DSO, used parts must be low cost and easy to obtain. For this reason, only common components like TL074 quad op-amp, CD4051 analog mux and ESP32 SoC are used.

- Input waveform is first conditioned according to user inputs and then sampled by STM32. Then it is sent to ESP32 to be processed. ESP32 draws the waveform on the screen and if the user wants it sends the waveform to a spread sheet file on the cloud. Then anyone with a link to the spreadsheet can view the waveform over the internet anytime.

Application Areas

- The main application area of the DSO is lab-at-home applications. Since commercial oscilloscopes are too costly and too advanced for students and hobbyists a simpler DSO would be useful. Student or hobbyist can buy parts of the DSO and build it on their own to lower costs and improve their soldering skills. And since they are the ones who build the DSO, they can omit features that they see unnecessary as they build it, like BNC connector for signal input or GPS module, or battery powered operation to cut costs. Teachers can do live experiments with their student over internet and get their measurements in one spreadsheet as students complete their experiments. Students can work on their projects without having to go to the university lab. And since the DSO is portable and battery powered it can be used on field. And if they are not omitted the GPS module, they can stamp their measurements with location data as well as time information.

Results and Discussion

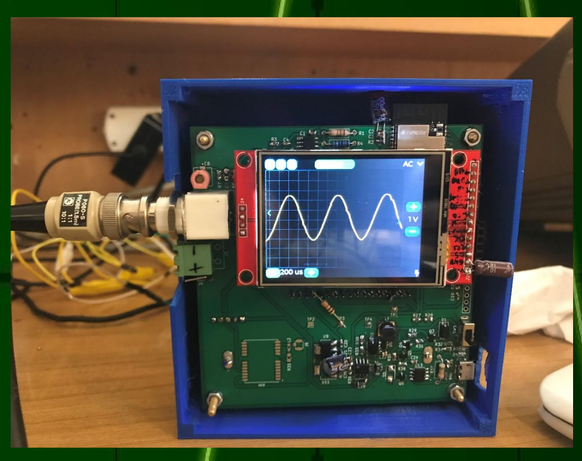

Figure 2

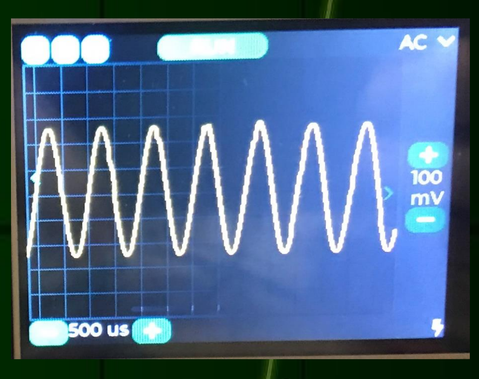

Figure 3

Input Voltage Range	(-7V) – (+7V)
Channel #	1
Analog Bandwidth	50 kHz
Fastest Sampling Rate	2 MHz
Memory Depth	1024 samples
Sample Resolution	12 bits
Max Rise Time	1 us
Screen Size	2.4 inch
Input Impedance	1 Mohm
Input Coupling	AC-DC
Trigger	Only DC

Table 1: Oscilloscope Specifications

Component Name	Price
ESP32 SoC	$4,30
STM32 MCU	$1,78
TFT LCD	$9,20
CD4051	$0,59
CD4053	$0,45
TL074	$0,80
ULN2003A	$0,50
BNC Connector	$2,00
TP4056	$0,13
ICL7660	$1,00
MT3608	$0,50
TC1262	$1,20
USB Connector	$0,20
PCB	$2,00
2000 mAh Lipo Battery	$4,90
BNC Connector	$1,00
Total $	$30,55

Table 2: Approximate Cost for Oscilloscope

- If the experiments are designed limits of this DSO in mind it can be used in classes. And for hobbyist use only input voltage range can be a problem an that can be solved by using a 10x probe.

References

- https://www.ti.com/product/TL074
- https://www.ti.com/product/CD4051B

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