Student sensor lab at home: safe repurposing of your gadgets

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Student sensor lab at home: safe repurposing of your gadgets
Outline

• Motivation: why repurposing home audio computing equipment
• Controlling the equipment
• Utilising ground loop isolators
• Connecting audio equipment to a custom circuit
• Using an external USB audio card
• Using Bluetooth audio
• Using Arduino
• Using custom hardware
• Conclusions
Why repurpose

• COVID-19 severely restricted lab use on university campuses
• Hands on labs experience is essential for training electrical and electronic engineers
• There is no economical way of supplying, maintaining and supervising students at home with a professional measurement equipment
• Most of common gadgets that students possess (smartphones, tablets, laptops, PCs) are equipped with decent quality stereo audio
• Although audio range is limited to 20 ... 20,000 Hz, these frequencies can be used for various sensor experiments, e.g. for Wheatstone and Wein bridges
Is it straightforward

- Unfortunately not because of the following main reasons
- safety of the learner (students can be very imaginative when using hardware; no university would want to get legally challenged because of H&S issues when operating laboratory instructions at home)
- protection of the expensive gadgets
Apps that can be used for measurements (1)

Christian Zeitnitz. Soundcard PC oscilloscope. [https://www.zeitnitz.eu/scope_en](https://www.zeitnitz.eu/scope_en)
Apps that can be used for measurements (2)

Digilent Waveforms – work with the PC audio inputs and outputs
Apps that can be used for measurements (3)

Function generator from KEUWLSOFT for Android.  
https://www.keuwl.com/FunctionGenerator/
Ground loop isolators

• Are used to reduce hum (mains and low frequency noise)
• Include transformer in every channel to isolate ground potentials
• Block DC with a capacitor (not present on the board)
• Up to 1.5 kV isolation stated in some datasheets
Not all the audio cables were born equal

- TS (tip-sleeve, mono) cables are not suitable
- TS may short the stereo outputs!
- TRS (tip-ring-sleeve, stereo) are fine
- TRRS - (tip-ring-ring-sleeve, full headset – stereo headphones + mono microphone) are fine too
Some audio cable sockets and adapters

• Are required to connect the isolated signal to a custom circuit (e.g. a breadboard)
• Can be barebone sockets
• Can have pin header
• Can have screw terminals
External USB audio cards

- Usually have headphone stereo output and mono microphone input with separate sockets
- Could be a full single TRRS socket though
- Some even have stereo line input
- CANNOT BE USED SAFELY W/O USB ISOLATOR
Using Bluetooth audio

- Fully wireless
- 2 channel stereo
- A separate transmitter and receiver are required
- Some have built in rechargeable batteries
- If not, use of power bank is recommended
Arduino Uno: Girino + Girinoscope

Girino - Fast Arduino Oscilloscope

- Firmware for Arduino
- 1 ch 40 kHz sampling
  *Must be used with a USB isolator for safety*
- No generator
- PC front end – Girinoscope from Github
- Usable but not polished
Two more options – USB isolators required!

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Conclusions

• It is possible to repurpose standard gadgets using off-the-shelf parts
• The easiest option is to use two ground loop isolators with a PC’s audio line input and output
• Inexpensive USB audio cards commonly provide only one channel microphone input, and require a USB isolator
• Bluetooth modules provide the best isolation but require two devices + two adaptors. For example, an Android phone sending the waveform to a BT receiver driving the circuit, and a BT transmitter acquiring waveforms to be sent to a BT equipped laptop
• Low-cost customised or bespoke developments are viable too