

Portable Impedance Tomography System

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Impedance as a Tool

- Complex Impedance Measurements provide insight on material composition.
 - More information can be observed using real and imaginary components.



Potential Applications

- Electromechanical Impedance Spectroscopy (EIP)
 - Characterization of coatings and metal corruptions.
- Electrical Bioimpedance Spectroscopy (EBIS) is a growing area of research.
 - Impedance pneumography- Respiration Rates
 - Continuous ECG measurements are subject to interference from motion artifacts.
 - Body composition measurements
 - **Electrical Impedance Tomography** – Using impedance to build a 2D/3D image of the material.

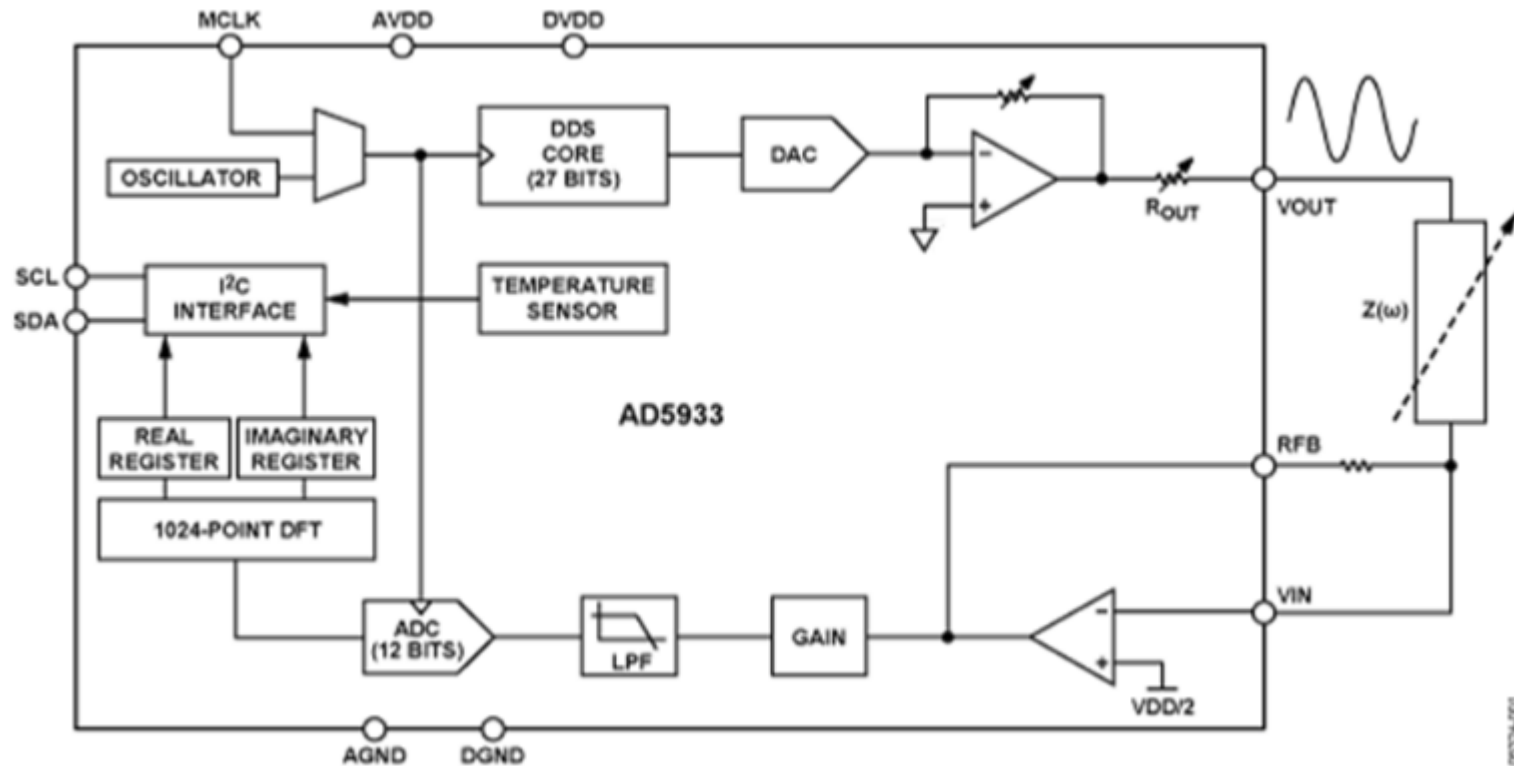


Analog Devices AD5933

- Low cost, impedance analyzer system on chip.
- Programmable output peak-to-peak excitation voltage to a maximum frequency of 100 kHz
- Programmable frequency sweep capability with serial I2C interface
- Frequency resolution of 27 bits (<0.1 Hz)
- Impedance measurement range from 1 k Ω to 10 M Ω
- Capable of measuring of 100 Ω to 1 k Ω with additional circuitry
- Phase measurement capability
- 2.7 V to 5.5 V power supply operation



AD5933 Block Diagram



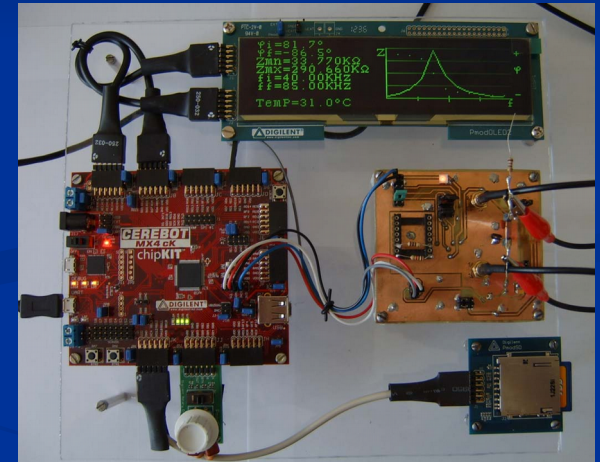
AD5933 Shortcomings

- The AD9533 front-end is not design for bioimpedance use.
 - Voltage driven interface without regard to current.
 - IEC-60601 defined current limits for human body.
 - Receive side has $VCC/2$ bias, therefor placing DC voltage on user.
 - 4 electrode measurement setup was introduced by Seoane et al.
 - Never disclosed the actual V-to-I and I-to-V conversion.



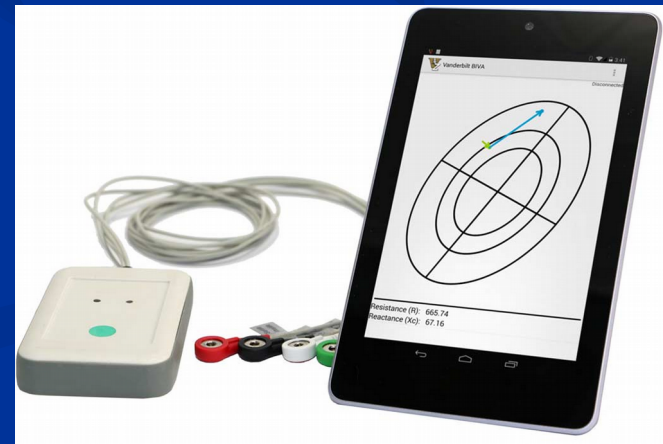
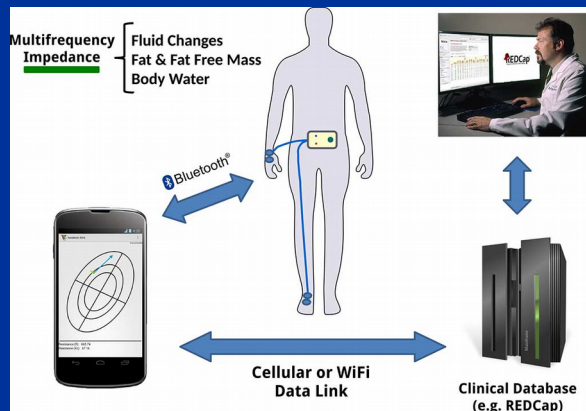
Breniuc et al.

- Wearable Impedance Analyzer
 - “Wearable”
 - Self contained UI
 - No front end additions



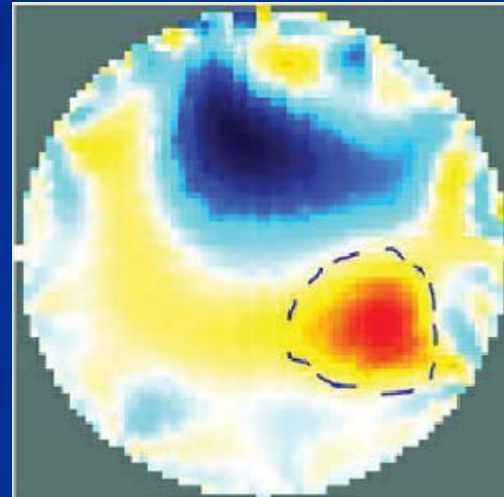
Harder et al.

- Presented a solution to measure fluid changes, and fat mass.
 - Developed a reliable body interface to the AD5933
 - Bluetooth connectivity



Dimas et al.

- 64-electrode Electrical Impedance Tomography system
 - Analog multiplexing 64 electrode system
 - Does not utilize AD5933



Proposed approach

- Portable Impedance Tomography
- Combine features of existing solutions
 - Multiple electrodes – 4 point
 - AD5933
 - Bluetooth connectivity



Logistics

■ Milestones

■ Hardware

- Platform Selection (19 SEP)
- Schematic Design & Layout Complete (26 SEP)
 - AD5933
 - Analog Multiplexers
 - Power Domain
- PCB Assembly Complete (10 OCT)
- PCB Checkout Complete (24 OCT)



Logistics

- Milestones (cont)
 - Software Development
 - Iterative deliveries based on SCRUM development cycles.
 - Sensor Module firmware development
 - GNU/Linux application development
 - (opt) Android application development



Philosophies

- Use and contribute free, libre, open source whenever possible.
 - PCB design will utilize KiCad
 - Design components will be submitted to official repositories.
 - GCC software compilation
 - Design and all document to be hosted at GitHub.
 - https://github.com/ashtonchase/portable_impedance_tomography



References

- L. Breniuc, V. David, and C. G. Haba, “Wearable impedance analyzer based on AD5933,” in 2014 International Conference and Exposition on Electrical and Power Engineering (EPE), 2014, pp. 585–590.
- R. Harder, A. Diedrich, J. S. Whitfield, M. S. Buchowski, J. B. Pietsch, and F. J. Baudenbacher, “Smart Multi-Frequency Bioelectrical Impedance Spectrometer for BIA and BIVA Applications,” IEEE Transactions on Biomedical Circuits and Systems, vol. 10, no. 4, pp. 912–919, Aug. 2016.
- C. Dimas, P. Tsampas, N. Ouzounoglou, and P. P. Sotiriadis, “Development of a modular 64-electrodes Electrical Impedance Tomography system,” in 2017 6th International Conference on Modern Circuits and Systems Technologies (MOCAST), 2017, pp. 1–4.

