

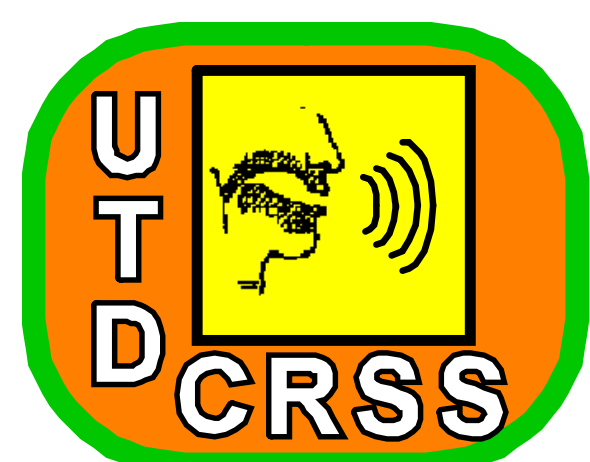
CCI-MOBILE: MOVING TOWARDS EXPLORING ADVANCED RESEARCH PARADIGMS FOR COCHLEAR IMPLANT AND HEARING AID USERS

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1. INTRODUCTION

- CCI-MOBILE platform supports synchronized bilateral electric & acoustic stimulation (EAS) for both acute and laboratory-based experiments for chronic field studies with cochlear implants (CIs) and hearing-aids (HA)
- USB/Wi-Fi research interface configured for both in-laboratory and field testing of sound processing strategies and/or data collection for CI/HA
- Plug-and-play system (portable, wearable, on-the-go signal processing adjustments)
- Supports unilateral/bilateral CIs and bimodal (Electric Acoustic Stimulation)
- CCI-MOBILE Research Platform is compatible with CIs manufactured by Cochlear Corporation

2. HARDWARE

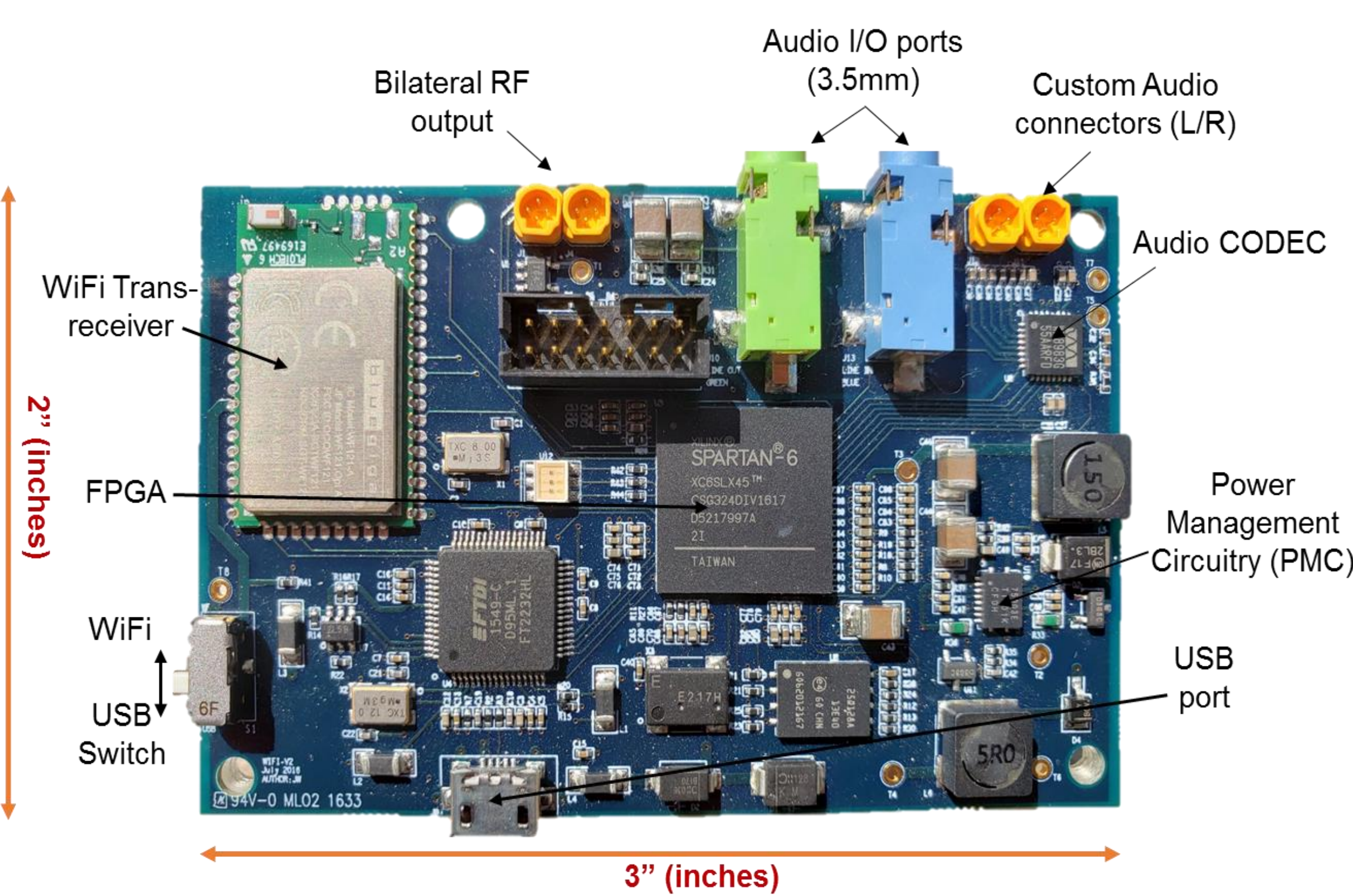


Fig 1. FPGA interface board for CCI-MOBILE.

- CCI-MOBILE consists of a custom-developed interface board that connects with a computing platform of your to stimulate CI24 implants (Cochlear Corp.)
- FPGA based interface board is programmed in Verilog equipped with:
 - 4-channel high quality stereo audio codec
 - USB/Wi-Fi support
 - Input/output ports for connection with clinical behind-the-ear (BTE) microphone units, Freedom headpiece coils, and audio I/O ports.
- Real-time performance (minimal processing delay) achieved via buffering of incoming and outgoing data on a frame-by-frame basis

3. FUNCTIONALITY

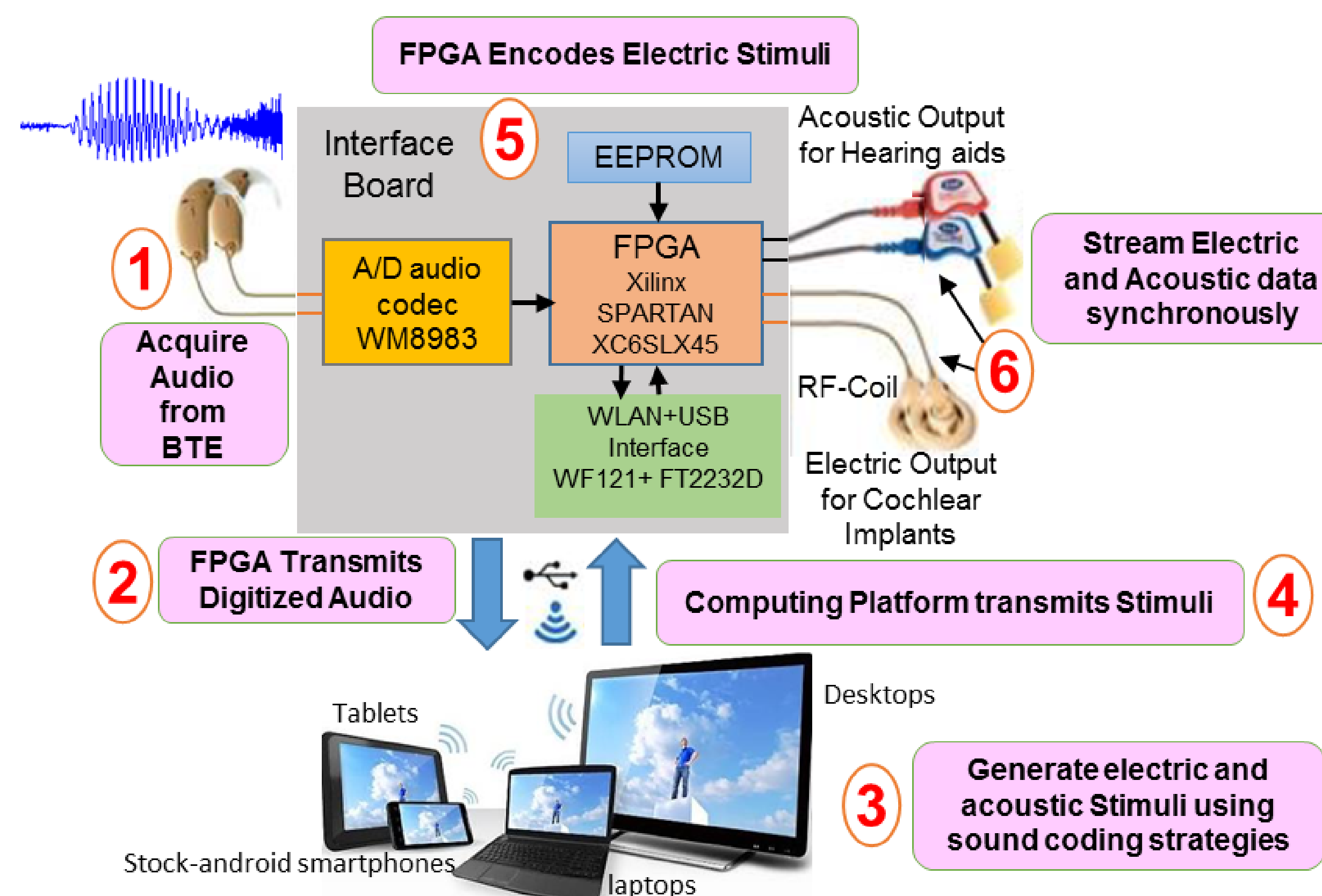


Fig 2. Processing flow of data communication for CCI-MOBILE.

4. WORKING SEQUENCE

- Hardware/interface board continuously samples incoming analog signals from BTE mic
- Digitizes 512 bytes of audio
- PC/smartphone processes digitized audio into electrical stimuli using signal processing routines
- Generation of electrical signals from electrical stimuli
- Streams data using proprietary communication routines (Cochlear Ltd.) on a frame-by-frame basis for CI24 cochlear implant systems
- For bimodal applications, acoustic and electric signals are sent synchronously

5. DESIGN FLOW

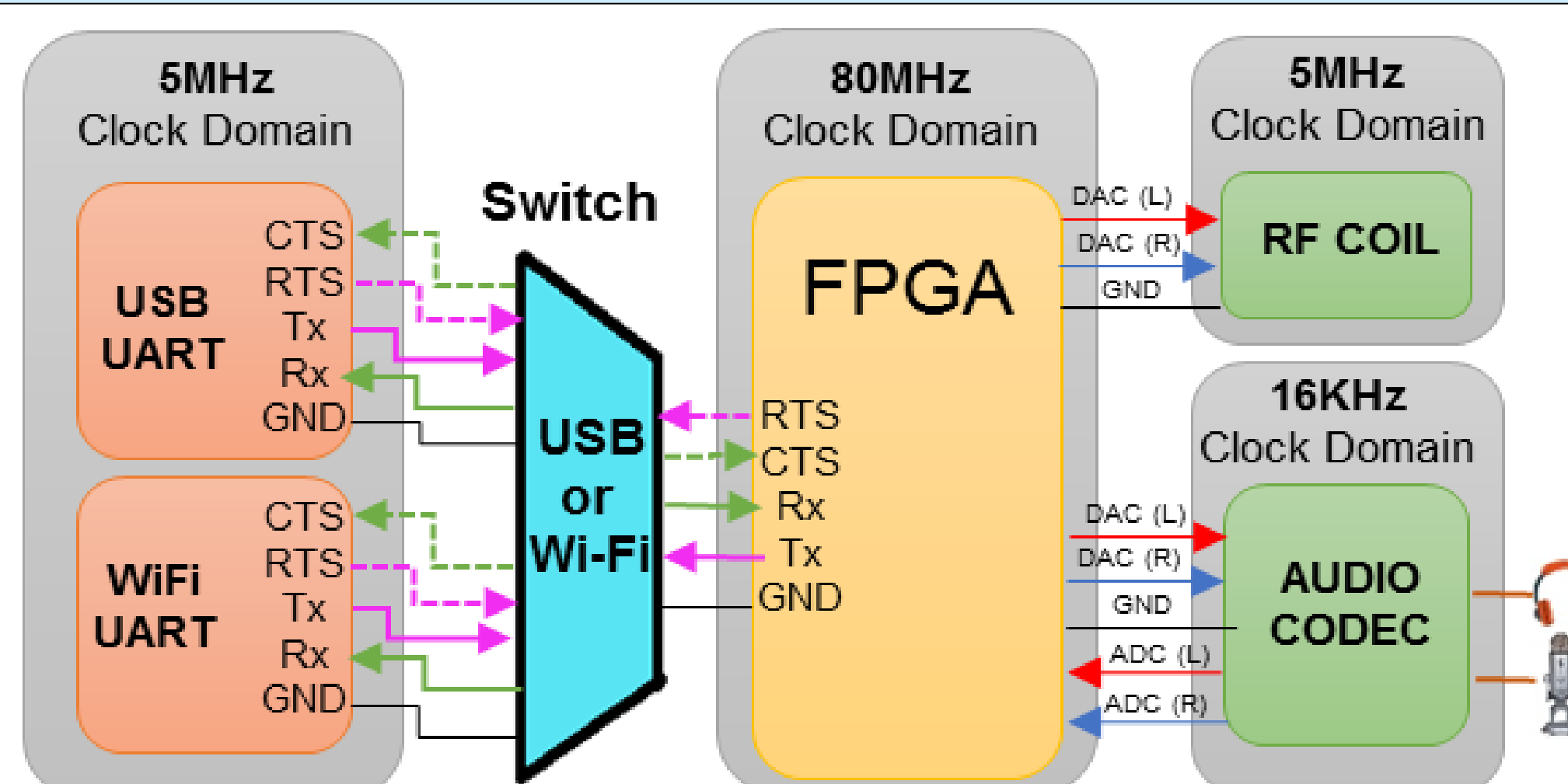


Fig 3. Hardware design architecture.

- Data synchronization managed via RAM and handshake design techniques
- Communication between computing platform and CCI-MOBILE at 5 Mbps

6. DATA TRANSMISSION

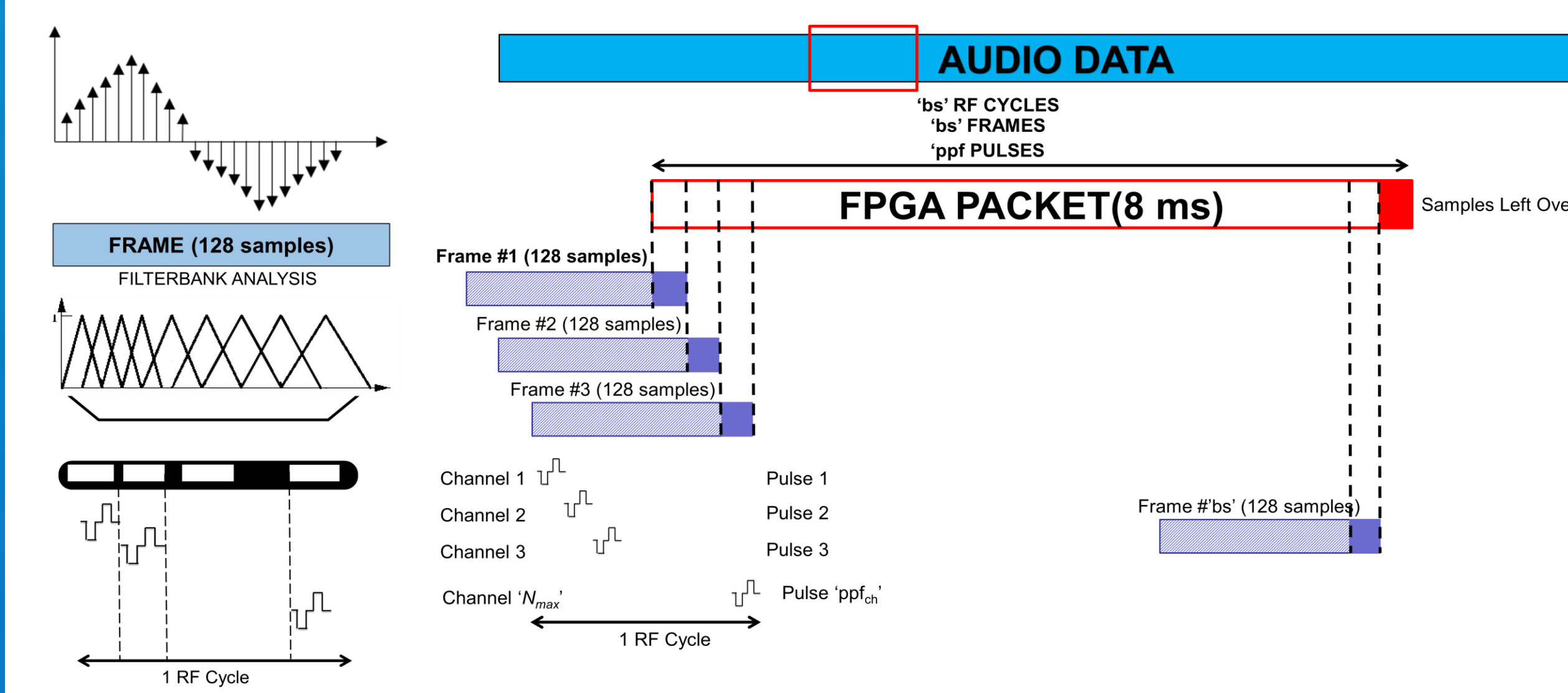


Fig 4. Incoming audio signal converted into FPGA packet.

7. OPERATING SPECS

Operating Voltage	5V
Audio Sampling Frequency	16KHz
USB Data Rate	5 Mbps
Audio frequency Range	200Hz – 8KHz
Current Consumption	0.14 A
Startup Time	10.4 ms + PC processing time
Frame Duration	8ms
Frame Size	1032 Bytes
	Electric – 516 Bytes
	Acoustic – 516 Bytes

Stim Rate (Hz)	Adjusted Stim Rate (Hz)	Total Stimulation Rate (Hz)	Adjusted Total Stimulation Rate (Hz)	Current Implementation (bytes)
1800	1778	14400	14224	112
1200	1143	9600	9144	72
1000	1000	8000	8000	64
900	889	7200	7112	56
850	800	6800	6400	48
700	696	5600	5568	40
600	593	4800	4744	32
500	500	4000	4000	32
250	250	2000	2000	16
125	125	1000	1000	8



Fig 5-6. Common stimulation rates supported (left). Time-synchronization of acoustic and electric signals (right).

8. CONCLUSIONS

- CCI-MOBILE is an open-source, flexible research platform compatible with cochlear implants and hearing aids (software shared on Github).
- Easy-to-use, adaptable applications and templates available for speech scientists in a high-language environment
- Suited to address multi-disciplinary hearing research topics such as: speech-in-noise, sound localization/lateralization, speech enhancement, custom environmental MAP changes, etc.
- Hardware & software verification routines ensure: (i) user control, (ii) safety, (iii) reliability of CCI-MOBILE
- Enables bench-top, in-lab, and field experiments for all speech and hearing scientists
- Website link: <https://crss.utdallas.edu/CILab/>