



Integrated Circuit to Record from Neurons in Cowbird Song System

By Sukhmani Grover | sukhmani@seas.upenn.edu | SEAS 2026

Advisors: Dr. Marc Schmidt, Department of Biology,

Dr. Firooz Alfatouni, Department of Electrical and Systems Engineering



Introduction & Goals

In songbirds, the 'song system' is the neural circuit responsible for song. The goals of this project are:

Short term: Electrodes surgically put in the song system are wired to a custom integrated circuit (IC) to record neural activity while the bird is anesthetized.

Long term: Wirelessly and continuously record from the song system with an implanted custom IC while the bird sings.

Materials & Steps

- PCB:** Design a custom printed circuit board (PCB) which allows proper connections for the same input signal from electrodes in brain to be amplified and securely transmitted to custom IC *and* to industry standard IC, and for an output to be connected to processor, which connects to computer.
- Intan IC, interface board, & software:** Use the industry standard – Intan – to compare custom IC's readings to. Use interface board and software to analyze and record the output of both.
- Electrodes:** Use carbon fiber electrodes so electrode is thin enough to prevent scar tissue from forming and obstructing signal quality. These electrodes must connect to PCB directly to reduce interference with signal quality, since signal is already small.

Progression

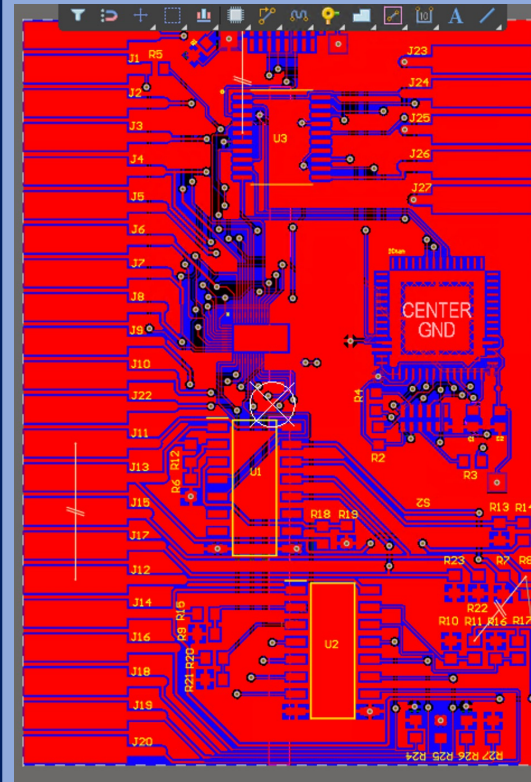


Figure 1: PCB designed to transmit neural activity to both ICs from brain, and then to computer to be read & analyzed.

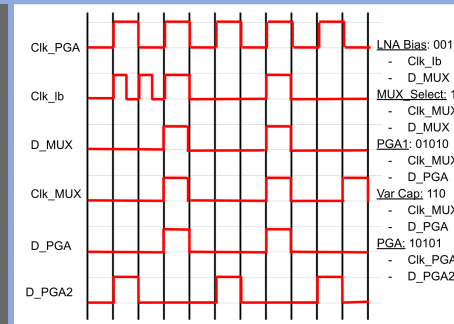


Figure 2: Graphical representation of Arduino code written to input signal for the purpose of setting certain parameters within the custom IC. One of 4 channels inputted.

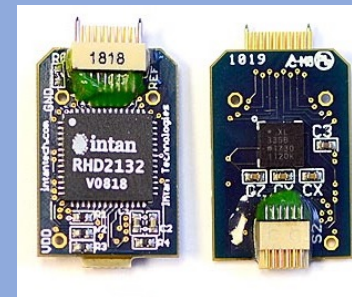


Figure 3: Intan IC on a PCB. Industry standard. Electrode signals fed in one end, RHD USB interface connected to other.

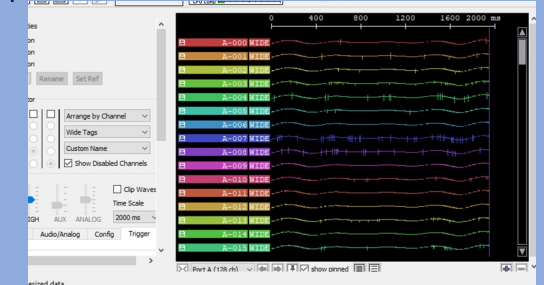


Figure 4: Neural signals appear as waveforms on Intan software.

Next Steps

- Bird operation:** implant electrodes into the bird's song system. Every two weeks, anesthetize bird, connect electrodes to PCB, and record neural activity.
- Compare readings from both ICs. Determine if custom IC is credible.
- Work on turning current IC into something implantable permanently.

Acknowledgements

I would like to thank Dr. Schmidt and Dr. Alfatouni for their kind support, to Claire Kendell for her mentorship, and to CURF for allowing me this opportunity through the PURM program.