PEPPER

A Brain–Computer Interface

HackaBull VII — Hardware Track Winner — April 2026

In 36 hours, a team of three students from PBA built a wearable that reads the human brain in real time. PEPPER captures electrical activity from the scalp, isolates the rhythms associated with focus, calm, and stress, and uses that signal to adapt the user's digital environment to their cognitive state. The project was born from a simple idea: instead of forcing the mind to adapt to its environment, the environment should adapt to the mind.

What lives on this wall is the analog front end. Everything that happens before software can begin.

The Signal Chain

Brain activity at the scalp measures in microvolts, roughly one millionth of a volt, buried under noise from muscles, mains power, and the electrodes themselves. Recovering it requires a precise sequence of analog stages, each solving a specific problem.

Instrumentation Amplifier (AD620). Two electrodes measure the difference between two points on the forehead. The AD620 amplifies that tiny difference by roughly 1000× while rejecting the noise common to both electrodes, isolated from the digital system by its own 9V supply.

High-Pass Filter (1µF, 330kΩ). Removes the DC offset that builds up at the skin–electrode interface, preserving only the time-varying brain activity.

Low-Pass Filter (4.7kΩ, 1µF). Cuts 60Hz mains interference and frequencies above the bands of interest.

Bias Network (10kΩ + 10kΩ + 10µF). Shifts the signal up to 1.65V so the ESP32's analog-to-digital converter can read it.

ESP32 Microcontroller. Samples the conditioned signal and streams it over Wi-Fi to a laptop, where AI agents interpret the brain state and act on it in real time.

Built by Dio Silveira (Palm Beach Atlantic University's first engineering graduate), Ethan Lawson, and Jacob Potantus.