Team 3: RF Display

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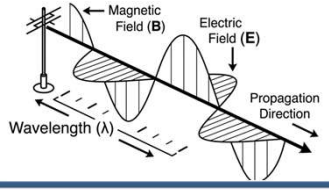
Objective & Problem Statement

To complement its existing high-end lab equipment, Phase 1 Engineering seeks a dedicated, permanent visual display for convenient, at-a-glance ambient RF monitoring and an engaging demonstration piece for clients and interns. To meet this need, a GVSU student team will design and build a wideband RF spectrum display using discrete RF block-diagram components. This device will capture and visually recreate local ambient signals, serving as an accessible secondary monitor, an educational tool, and a functional art installation.

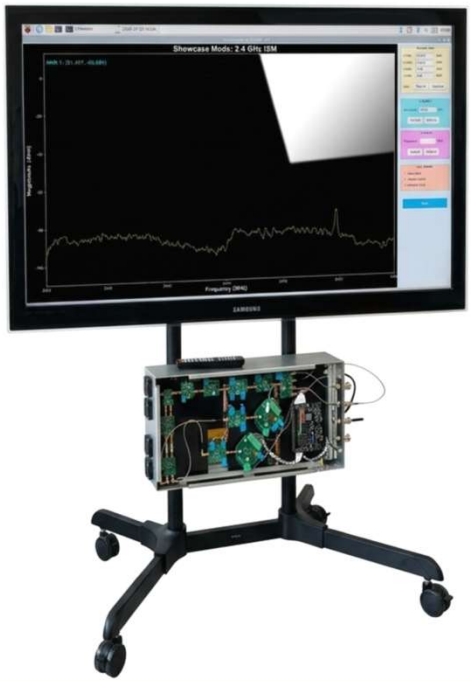
Background & Sponsor

RF engineering powers wireless tech like Wi-Fi, cellular networks, and radar. Visualizing the ambient RF spectrum is essential for diagnosing signal activity, interference, and hardware performance.

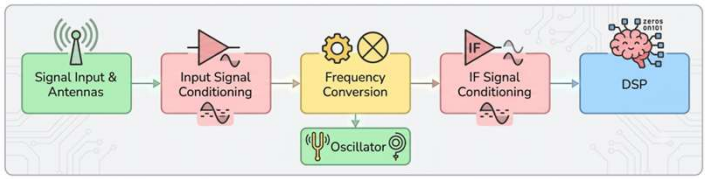


Based in Holland, Michigan, **Phase 1 Engineering** specializes in complex embedded software, custom PCB layout, and RF/antenna design. The firm delivers tailored electronic solutions from prototype to production and mentors emerging talent through GVSU partnerships and internships.

Design Approach



Sampling: Dual 12-bit ADCs simultaneously sample I/Q outputs.
FPGA Processing: Xilinx Spartan-7 manages deterministic timing and 4096-point FFTs, delivering 2048 positive-frequency complex bins
RPi 5 Processing: SPI streams data to a Raspberry Pi 5; algorithms perform FFT stitching across swept spans, gain and filter correction, and spectral averaging.
System Control: Python state machine on Linux RPi 5 queries FPGA, displays data, and commands RF hardware via SPI, I2C, and GPIO.



Architecture: Uses modular development boards per stage to reduce design risk and simplify testing.
Input & Conditioning: Receives 80-3000 MHz signals via four selectable antenna/test ports, followed by initial filtering and amplification.
Image Rejection & Conversion: Uses a two-stage hybrid process optimized for budget/component constraints:
Up conversion: Superheterodyne mixer converts signal to a 6.5 GHz IF.
IF Processing: Passes through a selectable filter bank, and dual LNAs to scale inputs for full-scale ADC capture.
Down conversion: Passive GaAs I/Q mixer outputs 10 MHz in-phase and quadrature baseband components.

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