**🚀 Full-Stack Engineering for Physical Systems: AI-Driven RF Testing with a £60 NanoVNA**

I developed a project that merges low-cost **Vector Network Analysis (VNA)** with **Deep Learning (DL)** to create an intelligent, data-driven RF analysis platform.

This is a demonstration of **Full-Stack Physical Systems Engineering**—the ability to engineer a complete solution, from the physical sensor layer right up to the advanced AI decision-making application. It proves that automated, high-level analysis, typically reserved for bench equipment costing upwards of **£5,000 to £20,000**, can be achieved with accessible hardware and a modern data science approach. Crucially, this core methodology of *Sensor-to-AI pipeline development* is directly portable across fields like Predictive Maintenance, Acoustics, Biomedical Monitoring, and Quality Control in manufacturing.

**🧠 Full-Stack Skill Breakdown:**

| **Layer of the Stack** | **Skill Demonstrated** | **Project Component** |
| --- | --- | --- |
| **1. Physical Layer (Hardware/Control)** | **Hardware Automation & Data Acquisition** | Automated S-parameter data collection from the **NanoVNA** via pynanovna (Python). Practical understanding of complex RF measurements, including **S-parameters** and rigorous standards like **SOLT calibration**. *This layer is equivalent to instrumenting any physical system (e.g., controlling a thermometer, oscilloscope, or industrial PLC).* |
| **2. Logic Layer (Data Pipelining/Processing)** | **Software Engineering & Data Integrity** | Building the **End-to-End** Python framework that streams raw RF data, handles preprocessing, and manages the data inputs for multiple complex models. Implemented an **Autoencoder** for real-time sensor self-monitoring (anomaly detection). *This robust data pipeline design is universal for any time-series or sensor data.* |
| **3. Intelligence Layer (AI/Application)** | **Deep Learning Deployment & Solution Architecture** | Designing, training, and deploying three distinct DL models (**1D CNN, Regression, Anomaly Detector**) to deliver tangible value: **Classification** (instant component identification) and **Prediction** (determining component values). *The application of Classification, Regression, and Anomaly Detection models is foundational to* ***Industrial AI*** *across all domains.* |

**💡 Core Project Outcomes:**

* **Accelerated Quality Control:** Instantly classifies components and predicts values directly from raw RF traces.
* **Guaranteed Data Reliability:** The Autoencoder proactively flags calibration drift, preventing costly measurement errors in a production environment.
* **Innovation & Accessibility:** Solves high-end RF analysis problems using low-cost hardware, showcasing capability for **scalable, efficient test automation** in sectors like IoT and Manufacturing. **This end-to-end framework represents a proven blueprint for implementing low-cost, intelligent monitoring systems in any industrial or engineering context.**

What I find most exciting is that this is just the beginning — imagine what is possible when we bring AI-driven intelligence to everyday lab kit!

📘 Full project architecture, methodology, and code are available here:

👉 [GitHub Repo Link]

#FullStackEngineer #RFEngineering #DeepLearning #IoT #HardwareAI #MachineLearning #Python #Innovation