GRINN

Grinn AI SDR Whitepaper

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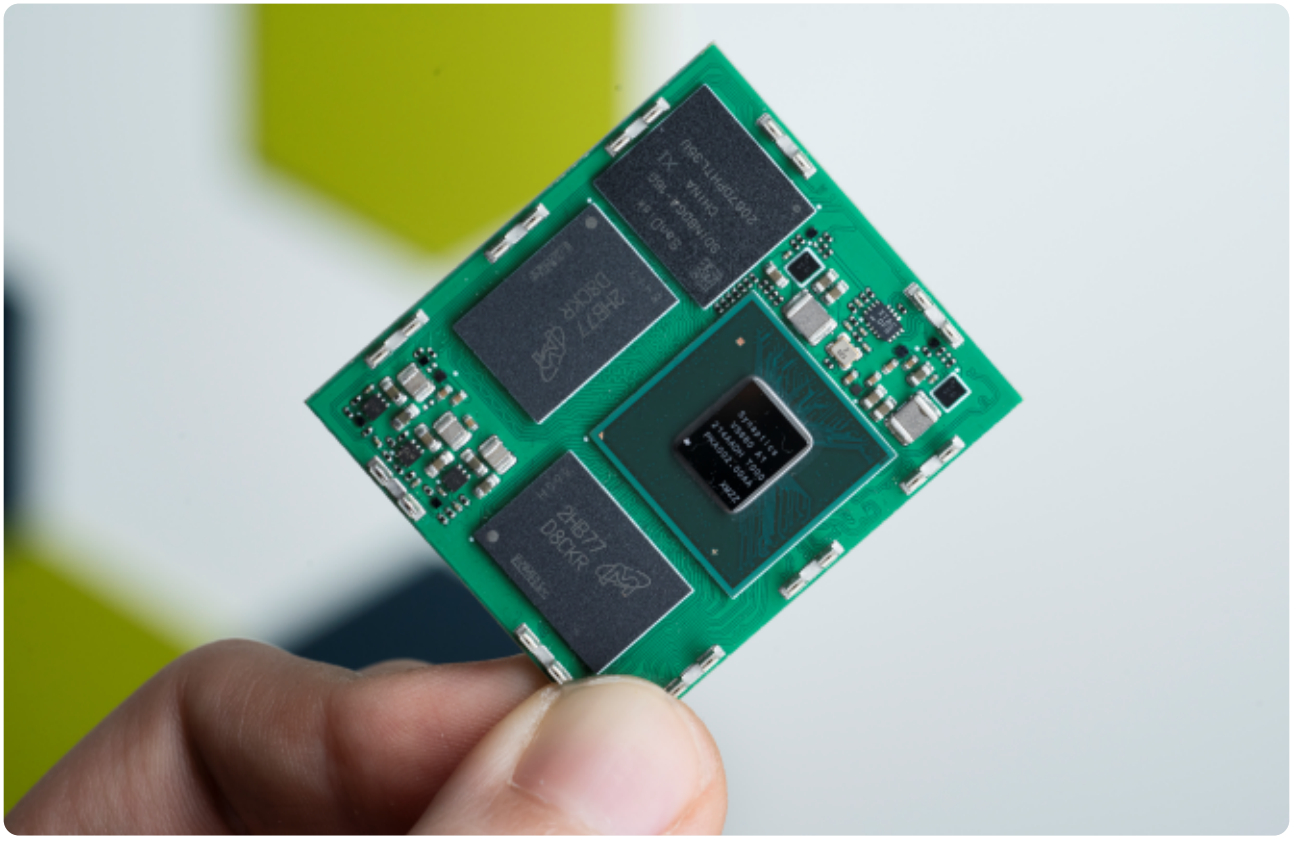
1 | Features



Radio wave spectrum analysis
Enables frequency domain analysis of captured signals

Compatibility with HackRF One SDR
Operates on an open-source hardware platform

Web application user interface
Uses a web application to display the waterfall plot and IQ constellation diagram

AI modulation classifier
Utilizes a custom-trained neural network model to classify recorded signals into one of seven modulation types

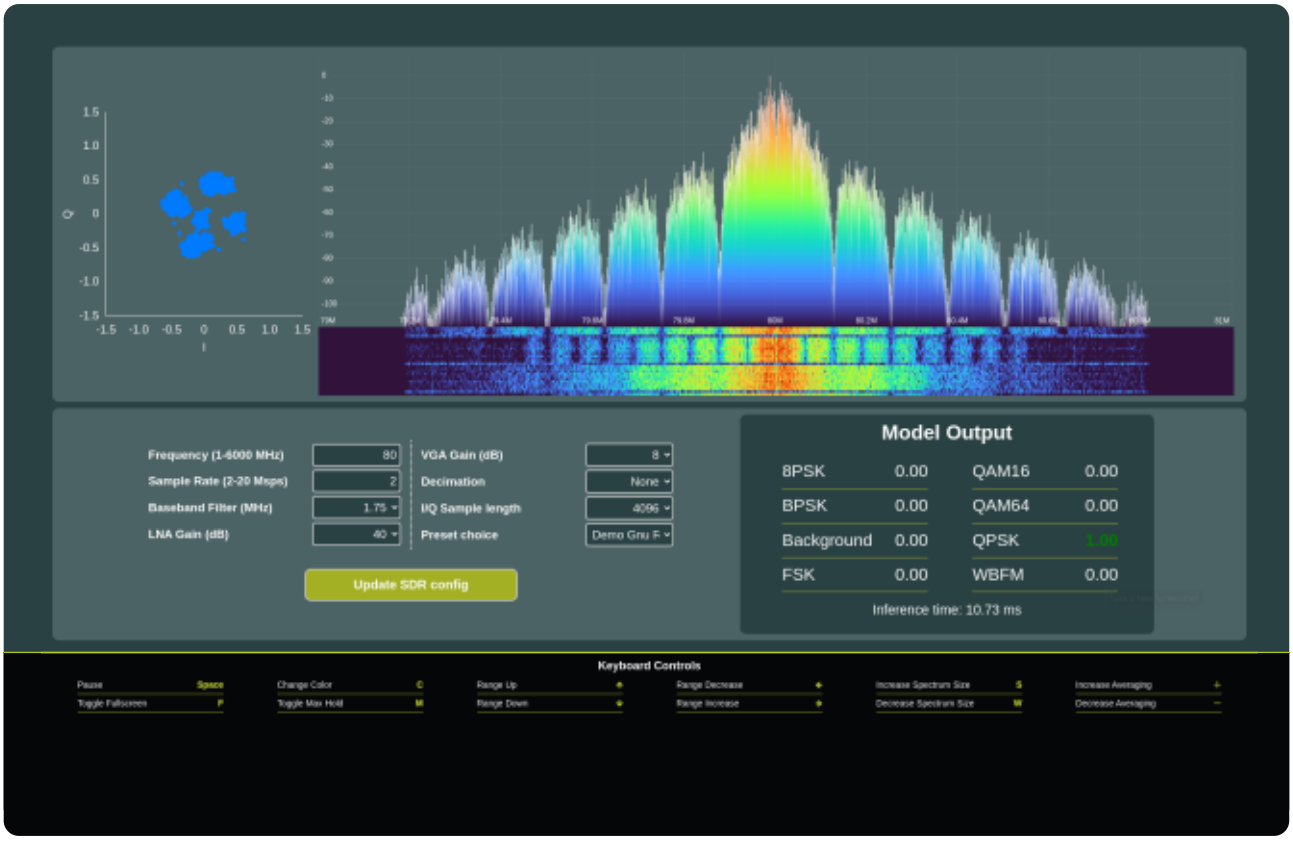
NPU acceleration
Utilizes the NPU integrated into the Grinn AstraSOM-1680 for efficient CNN model inference

Signals detection
Capable of detecting signals from FM radio, radio remotes, and wireless communication systems

Wide range of operating frequency
Allows setting the operating frequency in the range of 1 MHz to 6 GHz via the web application

SDR parameter configuration
Provides control over essential SDR parameters, including sample rate, base band filter, LNA and VGA gain, and decimation

2 | Description



AI SDR is a project build based on Grinn AstraSOM-1680, which revolutionizes radio signal processing by integrating AI-driven modulation classification with software-defined radio (SDR) technology.

This system enables real-time spectrum analysis and automatic identification of modulation types, leveraging edge AIfor efficient wireless signal processing. The platform utilizes a HackRF One SDR to capture radio signals, which are then classified into seven modulation types: 8PSK, BPSK, FSK, QAM16, QAM64,QPSK, and WBFM. A deep learning model, trained on synthetically generated data using the MobileNetV3 architecture, processes constellation diagram representations, with inference accelerated by the AstraSOM-1680's integrated NPU for real-time performance.

A web-based interface allows users to configure SDR parameters, visualize spectrum data through waterfall plots and constellation diagrams, and monitor classification results. The AI-SDR system has been successfully tested in detecting and classifying various wireless signals, including FM radio and remote control transmissions, demonstrating its potential in spectrum monitoring and wireless communication research.

3 | Case study

> In modern wireless communication, real-time signal analysis and modulation classification are crucial for spectrum monitoring, security, and adaptive radio networks.

The AI-SDR project, built on the Grinn AstraSOM-1680, integrates AI-driven modulation classification with real ime spectrum analysis, leveraging its Neural Processing Unit (NPU) for fast, power-efficient deep learning inference. With real-time signal detection, a web based visualization interface and compatibility with HackRF One, AI-SDR offers a flexible and efficient solution for spectrum analysis, wireless security, and RF intelligence applications.

3.1 | Example application

AI SDR showcases the capabilities of Edge AI in wireless signal analysis, providing real-time spectrum monitoring and modulation classification using a HackRF One SDR. The system continuously scans the radio spectrum, capturing and processing signals at the defined carrier frequency. With the support of a MobileNetV3-based deep learning model, AI-SDR identifies modulation types with high precision while leveraging the Neural Processing Unit (NPU) on the Grinn AstraSOM-1680 for efficient, low-power inference. By integrating AI-based signal processing, real-time visualization, this solution sets a new standard for intelligent spectrum analysis at the edge.

As wireless technologies evolve, the demand for real-time frequency monitoring and interference detection continues to grow. AI-SDR meets this challenge by utilizing the AstraSOM-1680's advanced AI processing to deliver fast, accurate signal classification without relying on cloud resources. The system seamlessly handles a variety of radio transmissions, detecting active signals, identifying modulation schemes, and offering real-time insights into spectrum usage. It can be used to detect and analyze radio signals from GSM mobile communications (3G, 4G, 5G), WiFi, and Bluetooth, making it an invaluable tool for wireless security, regulatory compliance, and RF research applications.

A web-based control panel enables users to interact with live waterfall plots and IQ constellation diagrams, providing a detailed view of detected signals and their characteristics. The SDR operates within a 1 MHz to 6 GHz frequency range, allowing full control over gain levels, sample rates, and tuning parameters for targeted signal analysis. As new transmissions are detected, the AI model running on device classifies modulation types instantly, presenting results with confidence scores and response times, ensuring a clear and actionable overview of spectrum activity.

The strength of this system lies in its ability to perform real-time AI-driven signal classification with minimal latency and maximum efficiency. The AstraSOM-1680's hardware-accelerated inference ensures continuous, high-speed processing, making it well-suited for applications requiring immediate signal detection and classification. The intuitive web interface integrates seamlessly with SDR operations, providing real-time visualization, precise control and instant feedback.

By merging AI-driven intelligence, advanced spectrum monitoring, and embedded processing, AI-SDR redefines the landscape of wireless signal analysis. This robust platform not only enhances spectrum awareness and security measures but also paves the way for more adaptive, high-performance, and efficient wireless communication systems in an increasingly dynamic RF environment.

3.2 | System benchmarks

The AI SDR system, powered by the Grinn AstraSOM-1680, was benchmarked to assess its efficiency in realtime modulation classification, leveraging the device for accelerated deep learning inference with minimal power consumption.

Inference speed

Utilizing the device's NPU for hardware-accelerated processing, the AI model executes classification in approximately 10 milliseconds, enabling real-time modulation identification without noticeable latency.

Classification accuracy

During a demonstration where another HackRF One SDR transmits signals modulated in predefined types via a nearby antenna, the system achieved near-perfect accuracy in classification, reliably distinguishing between different modulation schemes.

Constellation diagram processing

The system transforms IQ signals into constellation diagram heatmaps in approximately 15 milliseconds, ensuring rapid processing and analysis.

Power efficiency & hardware performance

By offloading inference to the AstraSOM-1680's NPU, the system maintains low energy consumption, making it an efficient solution for continuous RF monitoring and analysis in embedded applications.

3.3 | System benchmarks

The AI SDR platform, powered by the Grinn AstraSOM-1680, offers key advantages in wireless signal analysis and AI-driven applications through hardware acceleration and flexible configuration.

Complete development framework

AI SDR provides an end-to-end development environment for software-defined radio and AI-driven signal classification. With pre-trained model and a modular AI pipeline, users can fine-tune the system for different applications, including wireless security, spectrum monitoring, and interference detection.

Flexible and customizable SDR configuration

The system supports adjustable frequency selection (1 MHz – 6 GHz), gain levels, sample rates, and filtering options, making it adaptable to various signal environments. Users can configure the system for specific applications, such as wireless security monitoring or cognitive radio research.

Real-time visualization and user-friendly interface

The web-based control panel provides live waterfall plots and IQ constellation diagrams, allowing users to monitor signal activity and classification results instantly. The interface also displays confidence scores and inference times, ensuring a clear and actionable overview of detected signals.

Open-source SDR and AI integration

System is compatible with HackRF One, providing anaffordable, open-source solution for AI-based SDR applications. The platform supports custom AI model integration, enabling users to extend its functionality beyond modulation classification.

4 | Value proposition

The AI SDR platform, built on the Grinn AstraSOM-1680, delivers a powerful combination of real-time AI processing, advanced SDR capabilities, and open-source flexibility. By leveraging hardware-accelerated deep learning inference, it provides a robust and energy-efficient solution for wireless signal analysis, spectrum intelligence, and RF security applications. Its scalability, ease of integration, and high-performance processing make it a valuable tool for developers, researchers, and industry professionals working in wireless security, cognitive radio, and AI-driven RF applications.

4.1 | High performance AI for wireless signal analysis

Grinn AstraSOM-1680 powered by quad-core Cortex A73 processor combined with an integrated neural processing unit delivers high-speed, low-latency deep learning inference. The platform efficiently processes quadrature signals and modulation classification making it an ideal choice for applications that demand fast, intelligent signal recognition without cloud dependency.

4.2 | Advanced SDR capabilities and customization

System provides extensive control over software-defined radio (SDR) parameters, including carrier frequency setup gain adjustments, sample rate configuration, and filtering options. This level of flexibility allows users to tailor the system for specific signal environments, enabling applications in wireless surveillance, interference detection, and adaptive radio networks.

4.3 | Open-Source development and AI model adaptability

The AI SDR project is built on the open-source HackRF One SDR, ensuring an adaptable and extensible solution for developers. By leveraging open-source hardware and software, the system supports a wide range of modifications, custom integrations, and feature expansions, making it highly versatile for both research and real-world applications. The flexibility of an open-source architecture allows users to optimize software components, integrate new signal processing algorithms, and adapt the system for other applications.

The platform's compatibility with TensorFlow Lite provides access to an established ecosystem of machine learning tools and frameworks, enabling users to train, fine-tune, and deploy custom AI models for signal classification and RF analysis. This open environment fosters rapid prototyping, allowing developers to iterate and refine AI models to suit specific modulation schemes or evolving wireless standards.

5 | Contact

> If you're interested in the advanced capabilities offered by the AI SDR system build on Grinn AstraSOM-1680 for IoT, AI, or embedded systems applications, now is the perfect time to take the next steps and accelerate the development of your project.

Grinn - a team of experts in embedded systems development and artificial intelligence - is ready to support you in integrating Grinn AstraSOM-1680 into your solutions. Working with us will allow you to realize the full potential of this platform, optimizing implementation time and minimizing project risks.

Contact our support team

We will answer all your technical questions about Grinn AstraSOM-1680 and help you choose the optimal configuration.

Book a dedicated technical workshop

This workshop allows you to gain a deeper understanding of Grinn AstraSOM-1680's architecture and best practices for its integration and optimization for your project requirements.

Make an appointment for a free technical consultation

Our engineering team can arrange a demonstration session or meeting to show you the benefits of using Grinn AstraSOM-1680 in your project.

Download technical materials and documentation

We offer detailed specifications, implementation guides and application examples to help you better understand how our technology can support your innovations.

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