



Zaenex

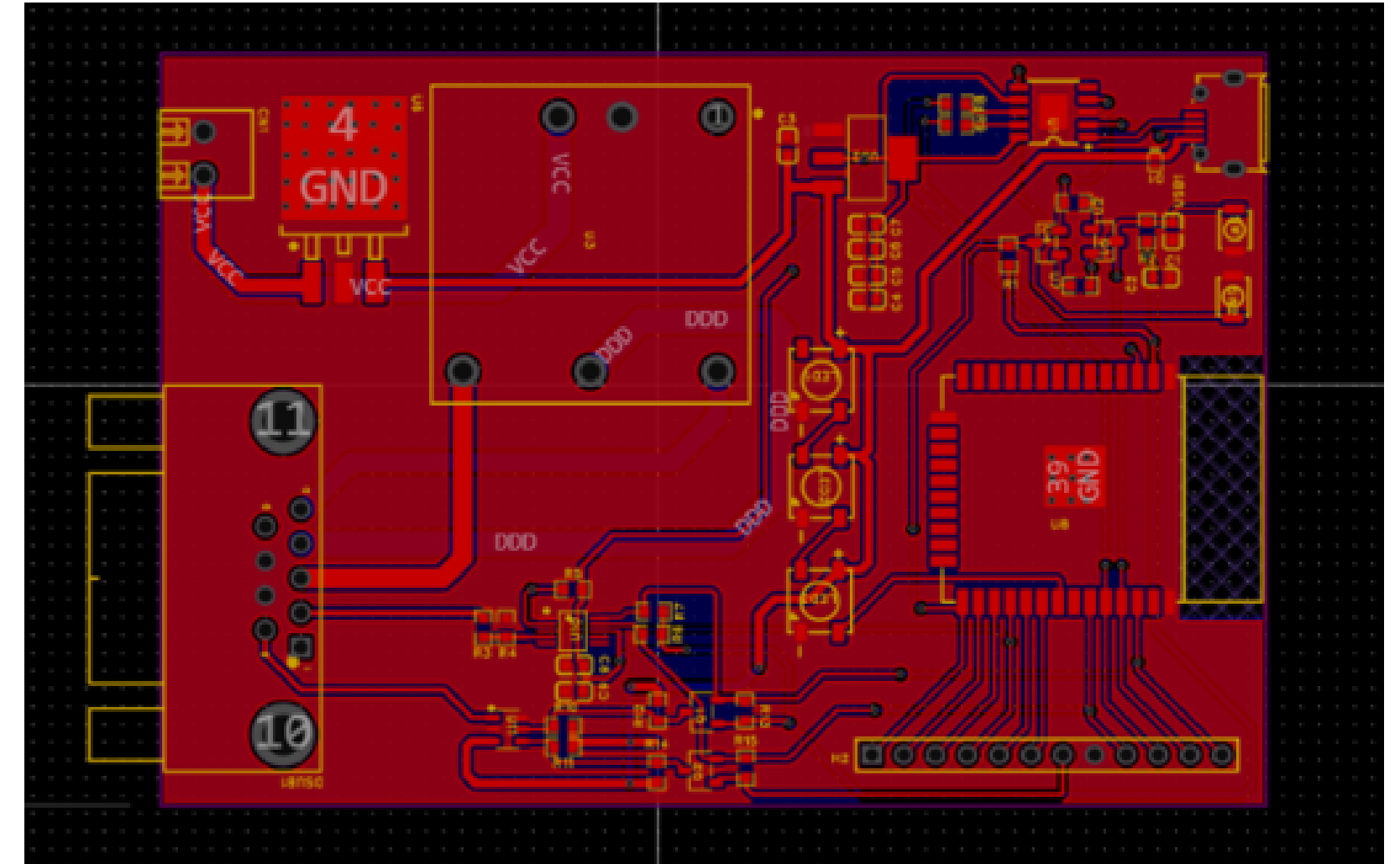
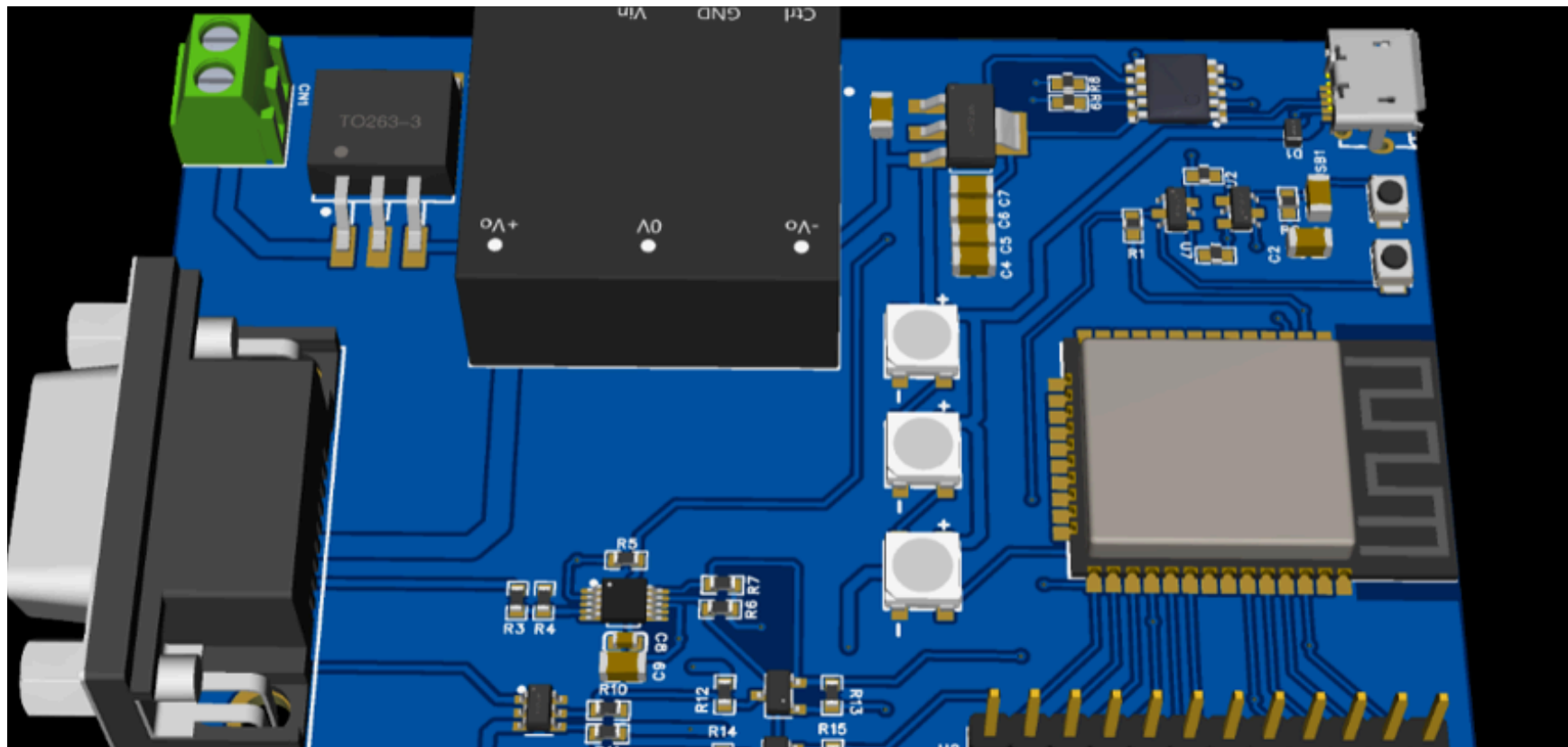
WELCOME TO ZAENEX PCB
DESIGN

ADVANCED PCB
DESIGN PROJECTS

Monitoring and Control System

IoT-Based Industrial Gas Leakage Monitoring & Control System using ESP32 & RS485

This is an IoT-based PCB designed to monitor and control gas leakage in industrial, commercial, and residential areas. It uses the ESP32 microcontroller with RS485 communication to connect gas sensors and control actuators like valves, alarms, and fans.



Usage & Application

Used in petrochemical plants, smart buildings, factories, cold storage, and parking areas for detecting gases like methane, CO₂, and CO.

PCB Layout Optimization

The layout is designed for high EMI immunity and long-distance RS485 communication (up to 1200 m). Proper trace separation, ground planes, and decoupling techniques are used to ensure signal integrity and power efficiency.

IR-Based Smart Scan

IoT-Based IR-Controlled Industrial Workflow System with Smart Scan Card Integration

This IoT-enabled system automates and secures industrial workflows using IR scan card technology. Controlled by an ESP32, it verifies authorized users and triggers machinery or workflow stages. Optional Wi-Fi support allows remote monitoring and real-time data logging.

Application Areas

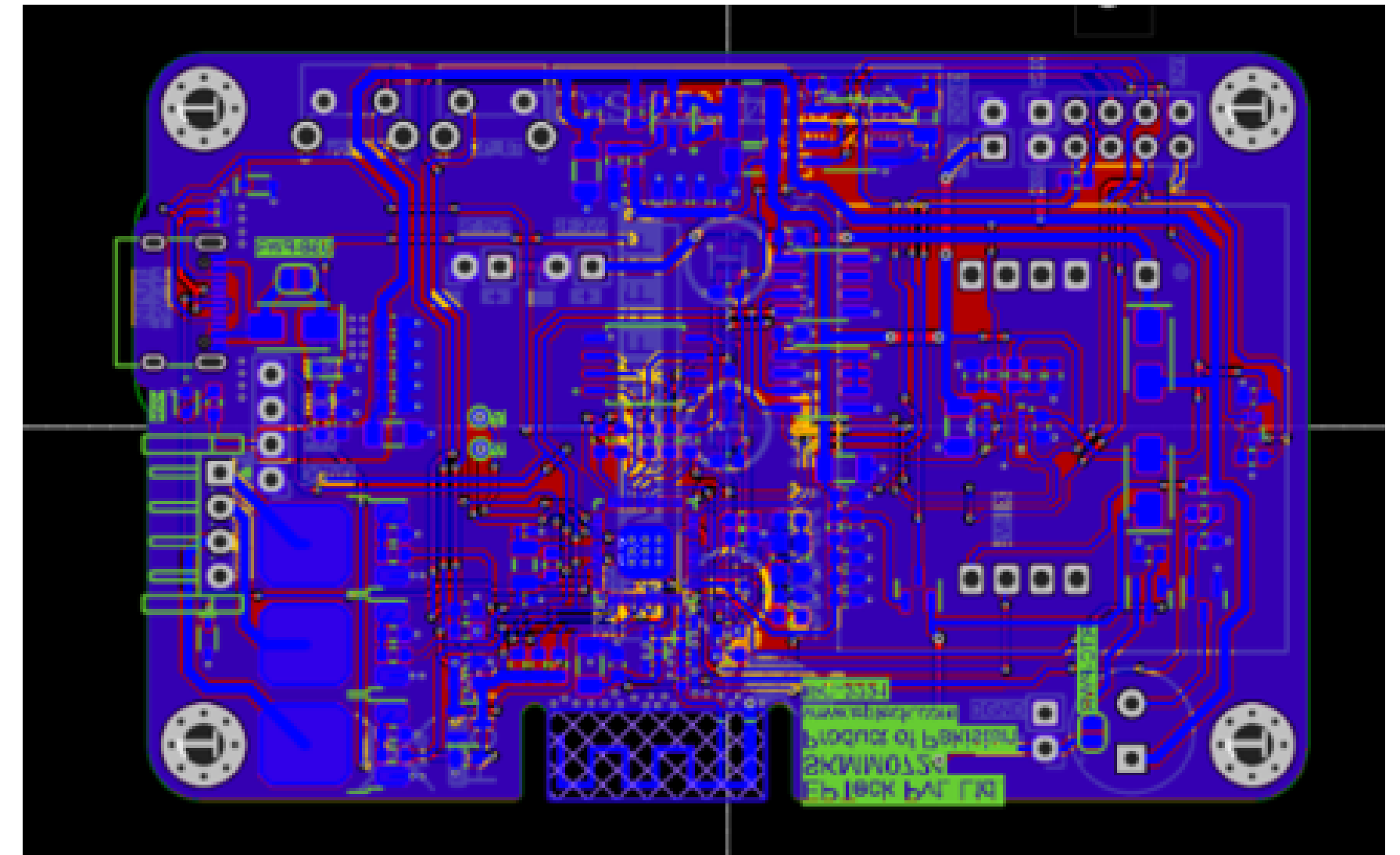
Production line control: Only authorized personnel can start or proceed with tasks

Warehouse access: Validates operators before allowing entry or system access

Maintenance zones: Logs who accessed or performed maintenance on machines

Attendance management: Contactless check-in for industrial staff

Quality checkpoints: Authorizes and tracks each step in the inspection process



Low-Cost Advantage

Compared to traditional RFID or biometric systems, this IR-based solution is much more affordable while still providing reliable and secure automation.

Far-Field Voice PCB Design

Custom PCB Design for xcore.ai 4-Microphone Far-Field Voice (FFV) System

The objective of this project was to design a precision PCB for the xcore.ai-based 4-Mic Far-Field Voice system, enabling advanced voice recognition, real-time noise suppression, and AI-based audio processing. The hardware supports robust voice interaction across diverse environments such as smart home assistants, industrial IoT systems, and intelligent audio platforms.

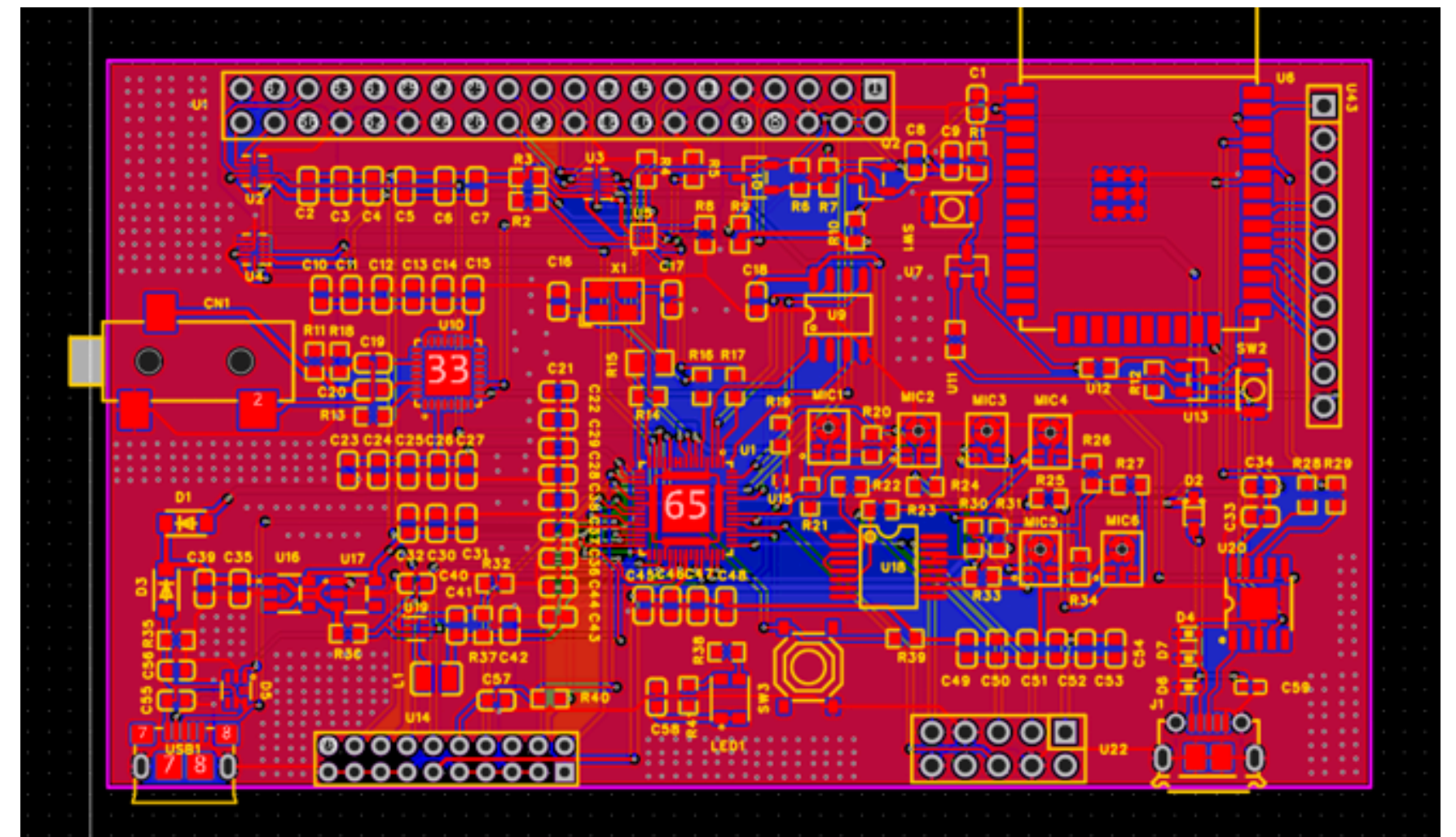
Signal Integrity

To ensure stable high-speed data transmission, the PCB was designed with careful signal integrity considerations. The 4-layer stack-up was configured as follows:

- Layer 1 (Top): High-speed signals (I2S, clocks, control lines)

- Layer 2: Solid ground plane for return paths and shielding
- Layer 3: Power plane (3.3V/5V) with well-placed decoupling capacitors
- Layer 4 (Bottom): Low-speed signal routing and debugging lines

Controlled impedance routing was implemented for I2S audio lines. Analog and digital domains were isolated to prevent interference, and ground stitching vias were placed to reduce EMI and ensure signal integrity.



Design Complexities

Differential pair routing for high-speed clock and data lines to maintain timing accuracy

- Short and direct trace routing to reduce reflection and latency
- Controlled impedance maintained across high-speed I2S traces
- Ground stitching vias used for EMI containment around critical signals
- Careful analog/digital separation to minimize cross-domain noise
- Mixed-signal layout handled with optimized component placement
- Compact design with dense routing managed for signal flow and thermal performance

Industrial Usage

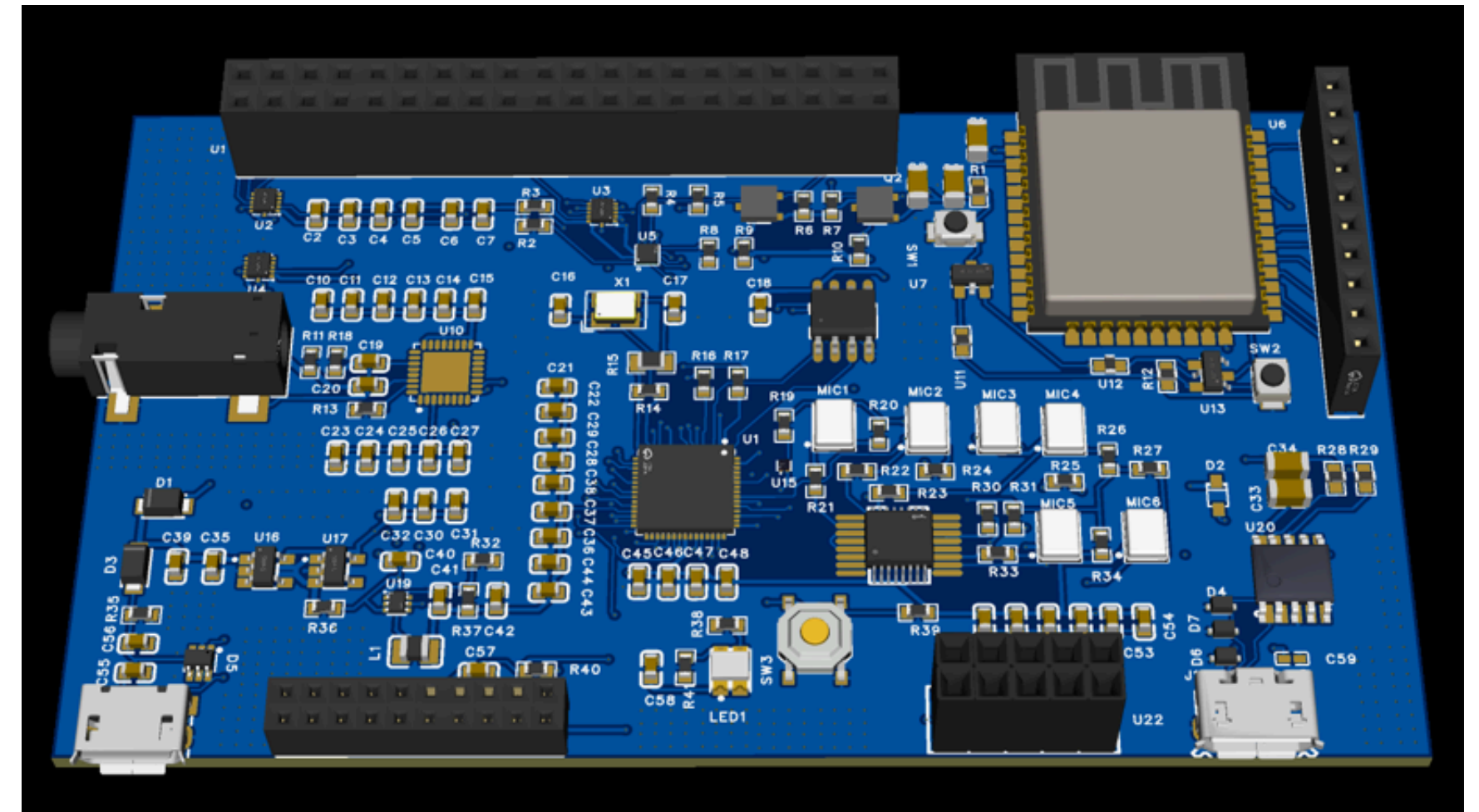
Smart Assistants: Far-field voice capture for home automation and personal AI devices

Voice-Enabled IoT Devices: Hands-free control in smart sensors and embedded systems

Healthcare Devices: Voice-guided user interfaces for diagnostic and monitoring tools

Conference Systems: High-quality voice input with echo cancellation and noise suppression

Industrial Automation: Operator voice command interfaces in noisy manufacturing environments



High-Speed PCB Design

High-Frequency 5G RF Network Circuit Design

Designed to support the high-speed, low-latency communication required in modern 5G networks.

Intended for use in high-frequency RF applications, especially in telecommunications infrastructure.

Provides enhanced bandwidth handling and signal performance in a compact circuit design.

Offers a cost-effective solution compared to similar high-performance RF modules

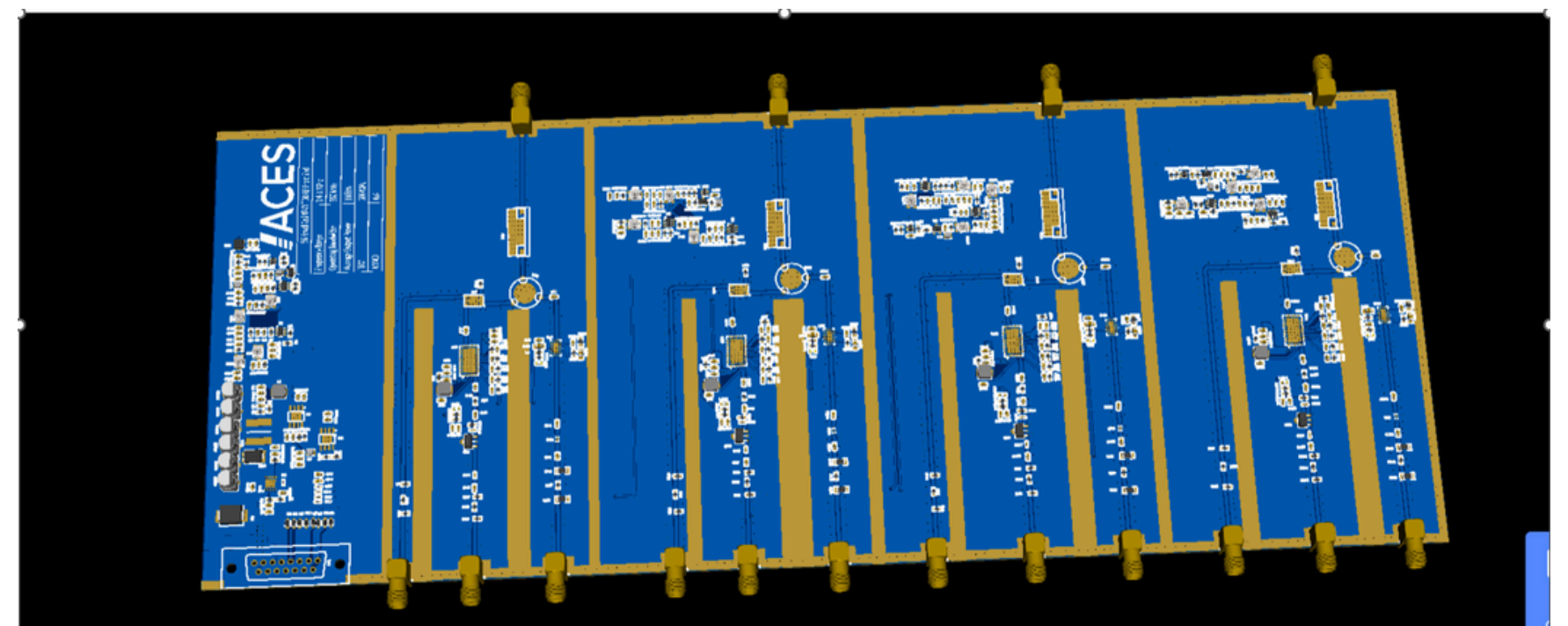
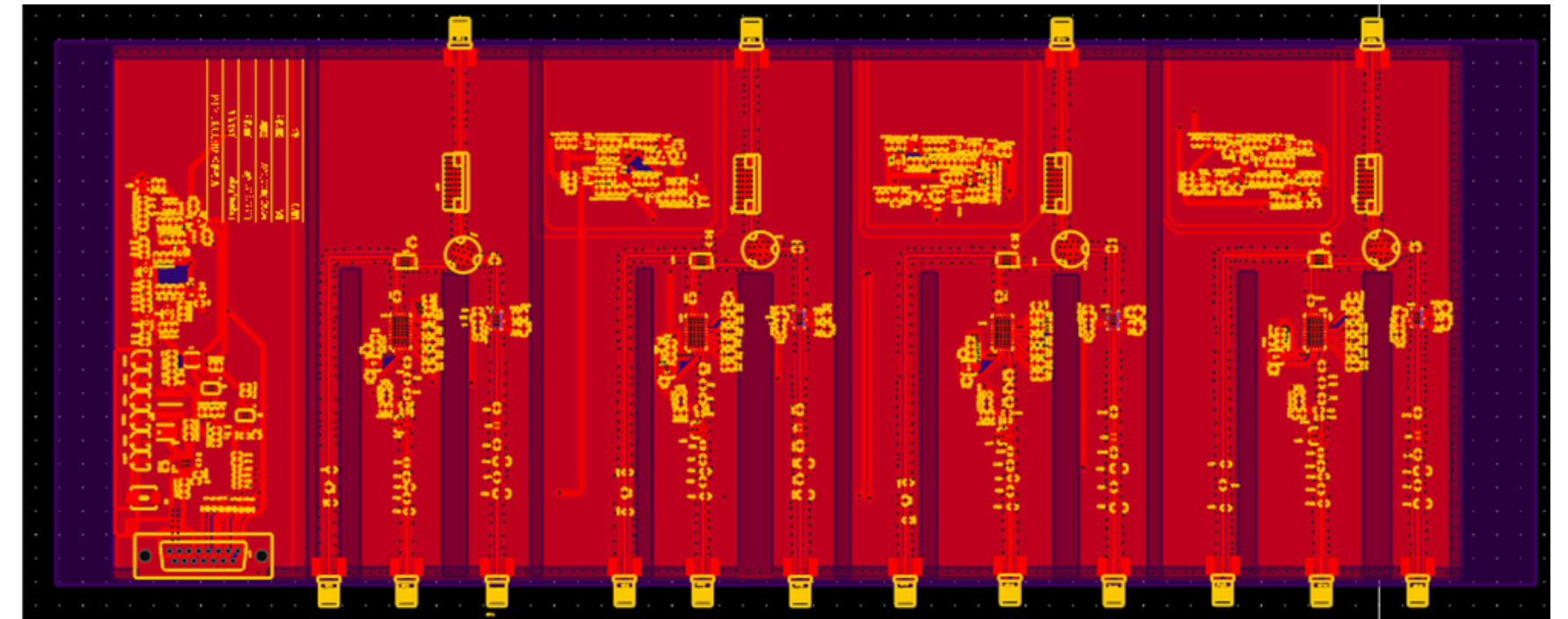
Design Complexities

Differential Pair Routing: Critical for maintaining phase and timing in high-speed RF signals.

High-Speed Signal Management: Handled frequency-sensitive paths with strict impedance control.

Via Optimization: Reduced signal reflections and discontinuities by minimizing via count and using via stitching for shielding

Component Placement: Strategic placement of RF components to avoid noise coupling and improve signal clarity.



Real time applications

- 5G Cellular Base Stations
- High-Speed Wireless Communication Modules
- Smart IoT Gateways for Industrial Applications
- RF Front-End Modules in Smartphones and Wearables
- Edge Devices in Smart Cities and Autonomous Vehicles

High-Density Flex PCB

Design and Development of a High-Density Flex PCB

Design Complexities

Track Optimization: Carefully routed narrow and curved traces to maintain signal quality within the flexible layout.

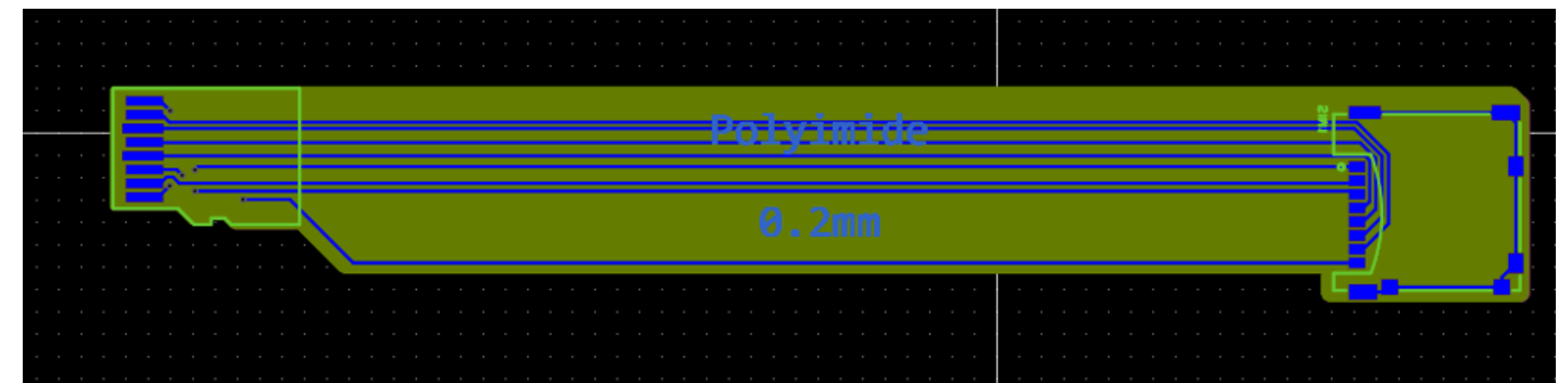
Manual Routing: Avoided autorouting; manually routed all critical paths to ensure precision and reliability under bending conditions.

Signal Integrity: Followed best practices for impedance control, minimized crosstalk, and reduced EMI issues.

DFM Considerations: Designed with flexible PCB manufacturing tolerances in mind—optimized pad sizes, hole-to-copper clearances, and material stack-up.

Bend Reliability: Maintained critical bend areas clear of vias and stress points to increase PCB lifespan under dynamic movement.

It Routing: Strategically routed high-speed and sensitive signals to avoid noise coupling, using ground shielding where needed.



Rigid-Flex PCB Design

IoT-Based Rigid-Flex PCB for Strain Gauge Monitoring

This Rigid-Flex PCB is designed for an IoT-based strain monitoring system using a combination of **SW-520D**, **HX711**, and **ESP32** to measure vibration and strain data and wirelessly transmit it over WiFi. The design merges flexibility with durability, allowing it to operate in constrained mechanical spaces while ensuring accurate data sensing

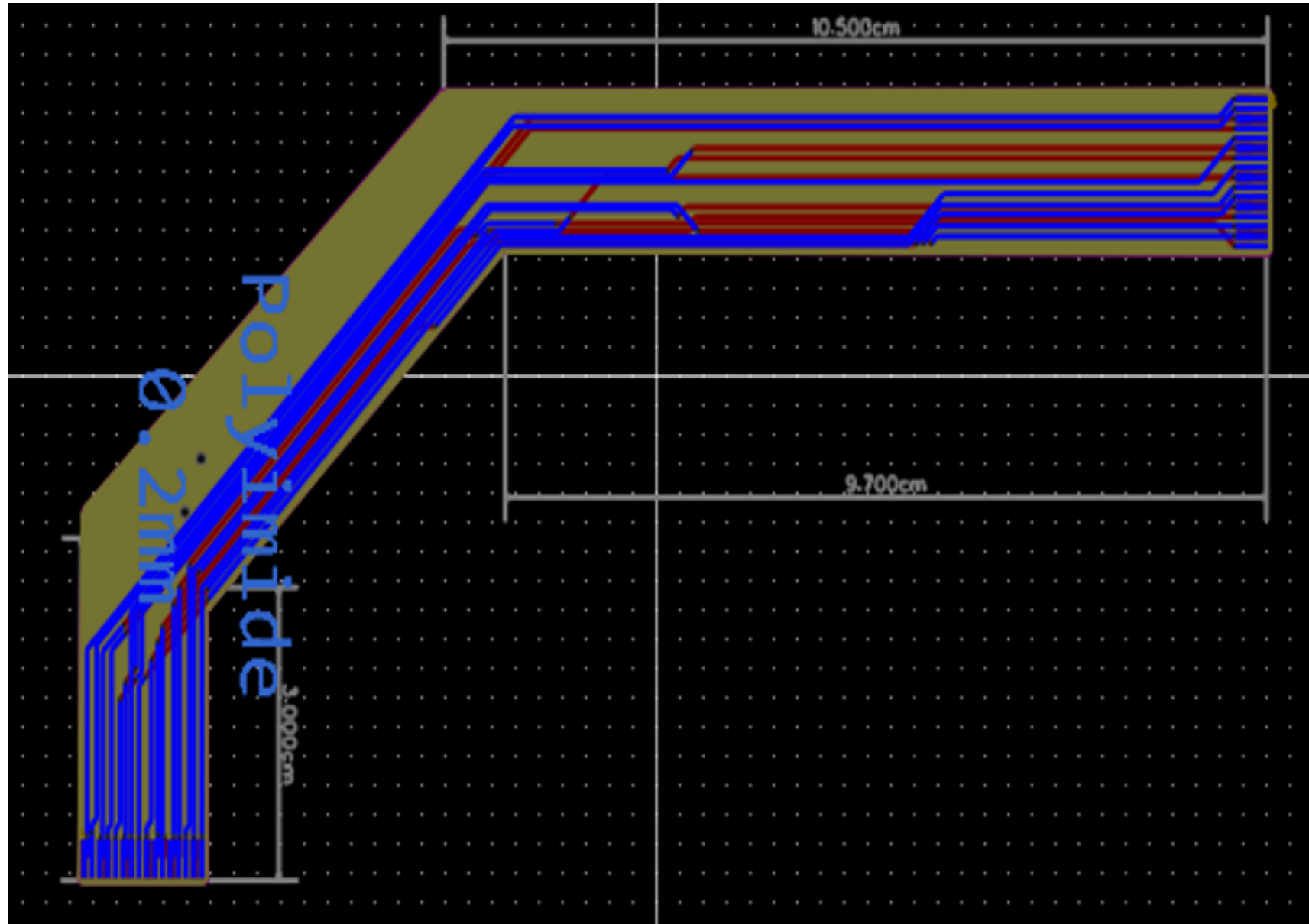
Design Complexities

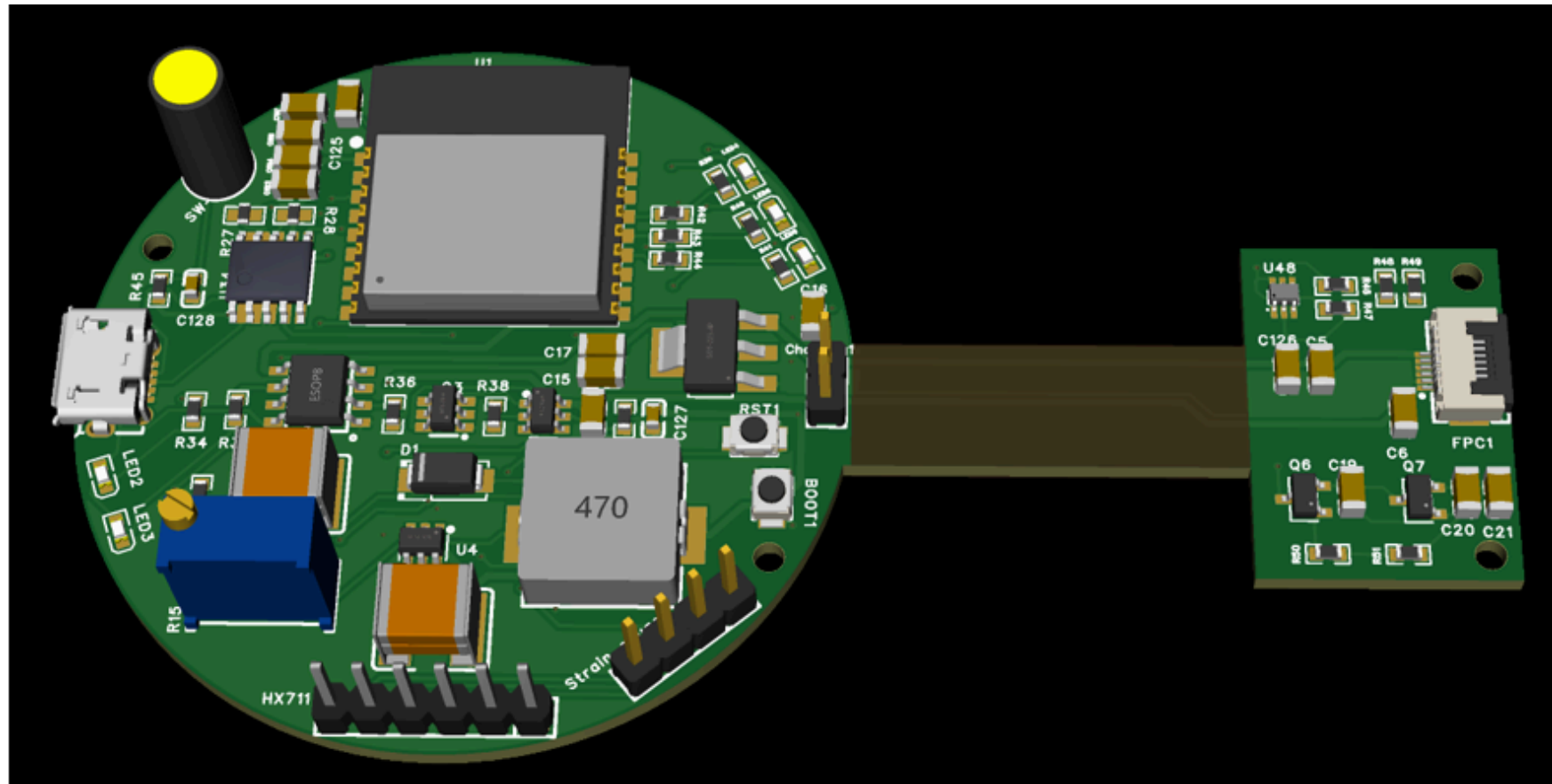
DFM (Design for Manufacturing) Optimization: Carefully routed to match manufacturing capabilities while maintaining signal reliability. Controlled impedance and stackup tuning were considered to meet fabrication tolerances.

Cost Optimization Techniques

Layer Minimization: Reduced unnecessary layers while maintaining performance, thereby cutting material and processing costs.

Component Selection: Used cost-effective, readily available SMD components without compromising functionality.



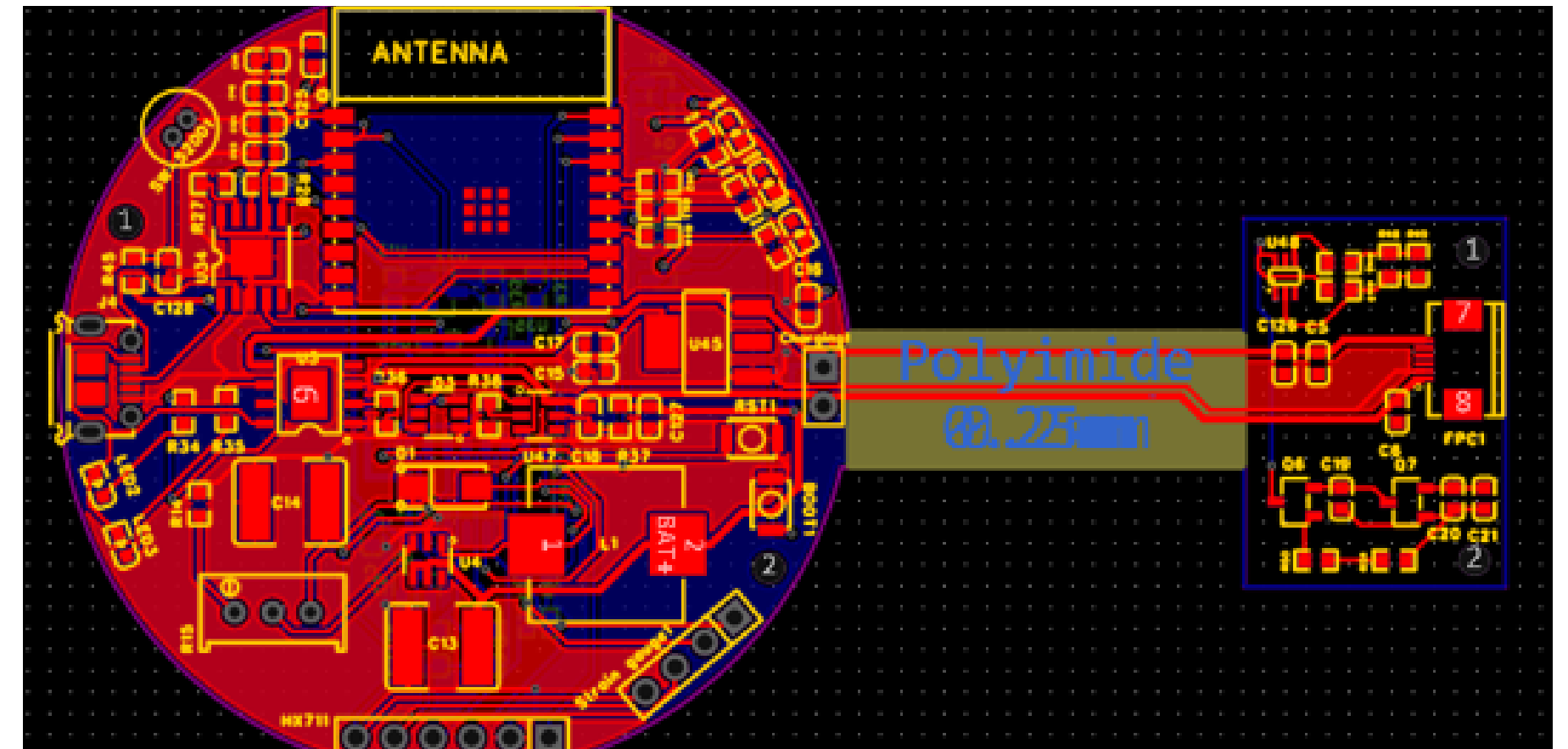


Signal Integrity: Differential pairs for HX711 were kept short and shielded. Ground planes and via stitching were strategically placed to minimize crosstalk and reflection.

Power Optimization: ESP32 and HX711 were power-profiled to reduce overall power consumption. Low dropout regulators and decoupling capacitors ensured stable voltage.

Noise Reduction: Analog signal paths were isolated from noisy digital areas. Ground loops were avoided by star grounding and filtering techniques.

Flex Area Routing: Trace width and bend radius were optimized in the flex region to prevent mechanical stress and cracking.



Cost Optimization

Minimized board size to under 25mm, significantly reducing material cost.

Component selection balanced between performance and cost (e.g., low-cost but accurate HX711).

Single-sided component mounting where possible to reduce assembly charges.

Optimized layer usage in the rigid and flexible zones to reduce fabrication complexity.

Nano PCB Design

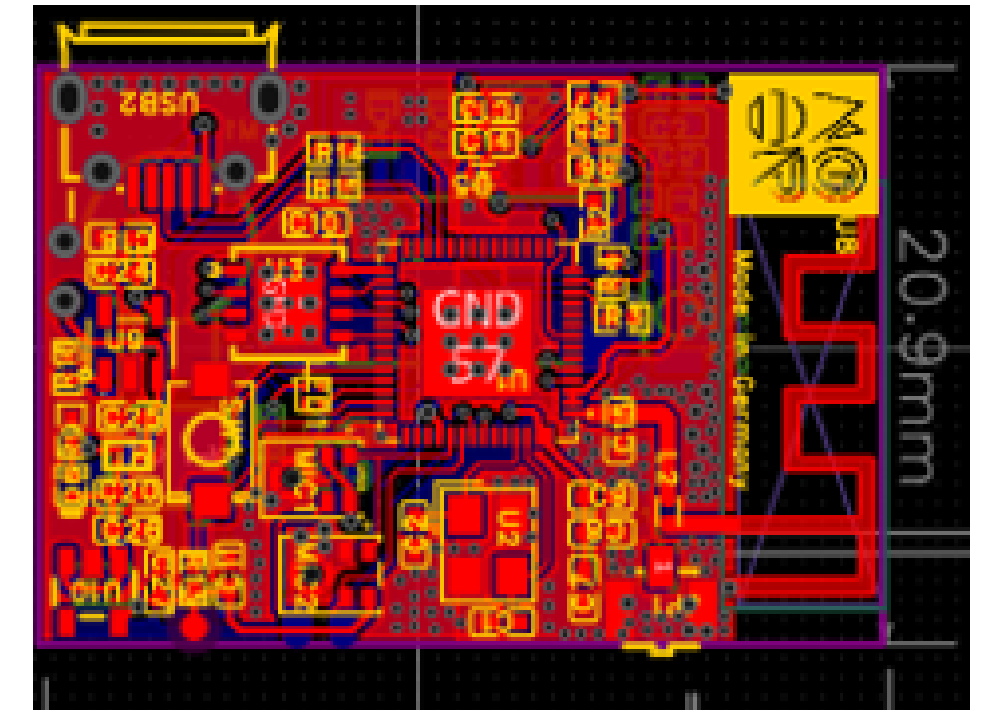
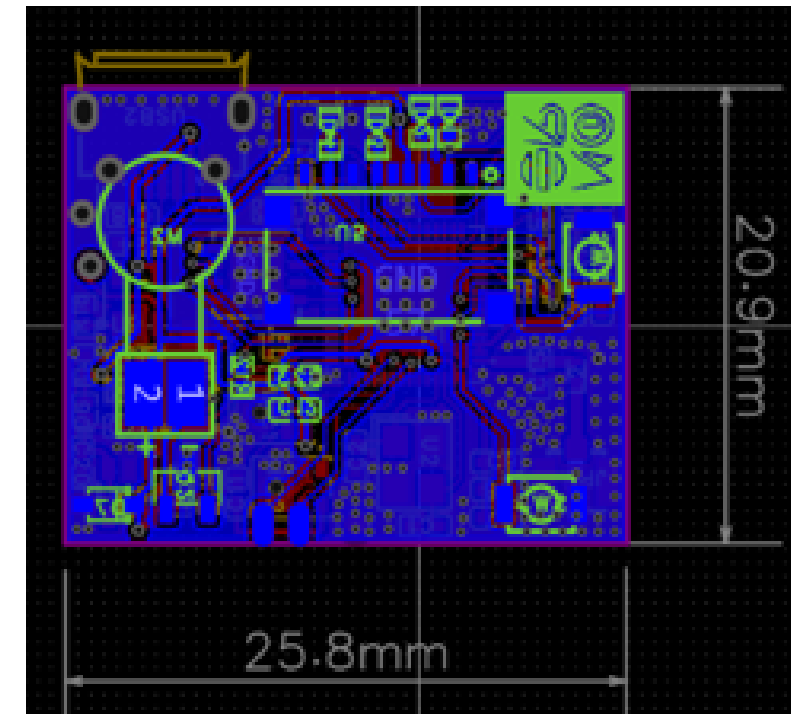
Nano PCB Design for Compact Applications

Design Complexities

- Designed within an extremely limited space (~20–25 mm)
- Used compact and high-density components (e.g., 0201 passives, fine-pitch ICs)
- Ensured thermal dissipation in tight spaces using thermal vias
- Achieved efficient grounding using internal layers and via stitching
- Focused on low EMI layout and tight return paths
- Manually routed critical traces due to tight clearances and high-speed signals

Design Optimization

- Optimized track width and spacing according to IPC standards for miniaturized PCBs



- Used multi-layer stack-up to separate power, ground, and signal layers efficiently
- Chose low-profile components to reduce Z-height for wearables/IoT-like use
- Applied DFM guidelines to avoid production errors on such a small board
- Reduced via count and layer transitions to improve signal integrity and simplify manufacturing

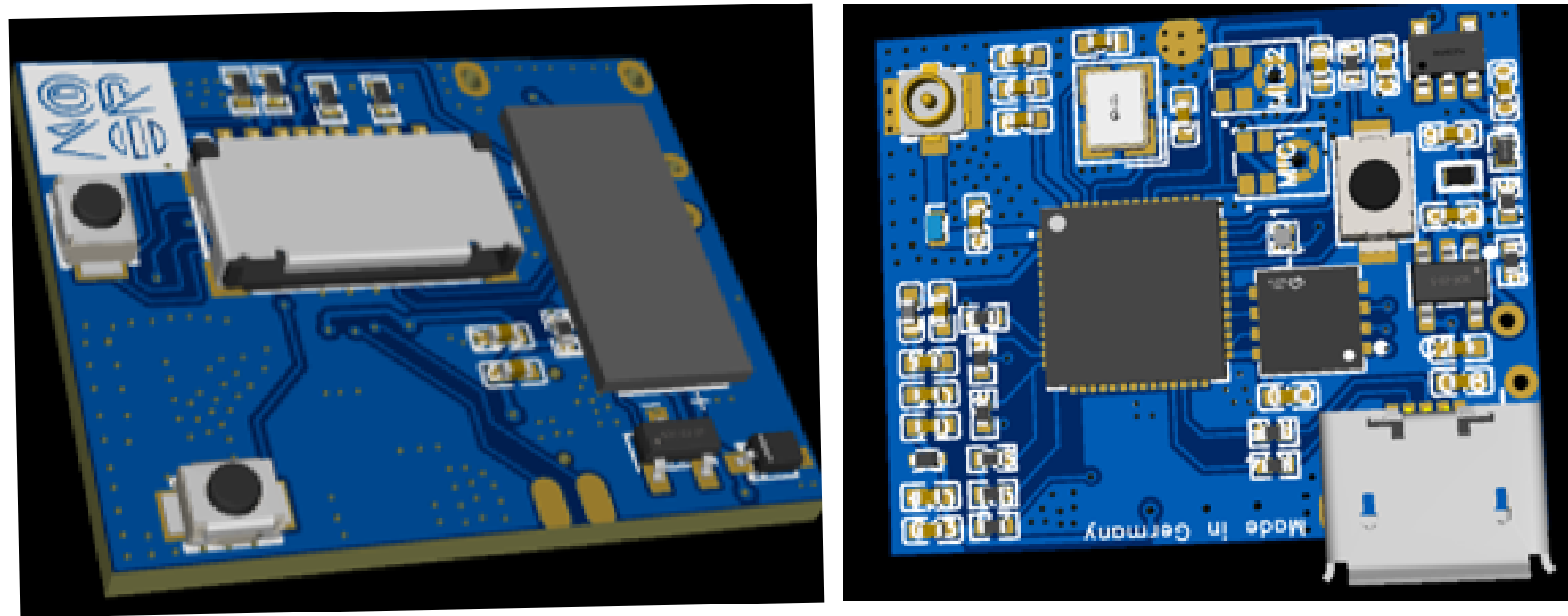
Cost Reduction

- Used a 2 or 4-layer stack-up instead of expensive 6–8 layer setups
- Selected commonly available components with small packages

Combined functionality into fewer ICs to reduce part count

Used panelized designs for batch fabrication to reduce per-unit cost

Avoided laser vias and blind/buried vias to keep fabrication simple



Manufacturing & Production Handling

Ordering a PCB isn't just "click and buy" it involves several complexities such as selecting the correct layer stack-up, choosing appropriate copper thickness, defining minimum trace widths, ensuring controlled impedance for RF designs, and matching the fabrication capabilities of the manufacturer.

There are also challenges in material selection (e.g., FR4, Rogers, or hybrid materials) based on high-frequency performance, surface finish types (HASL, ENIG, Immersion Silver), and via structures (through-hole, blind/buried vias, microvias).

- I handle all these decisions for you ensuring your Gerber and manufacturing files match the chosen PCB factory's capabilities, so there are no production delays or costly redesigns.
- I verify design-for-manufacturing (DFM) compliance before sending files to production.
- I manage BOM matching, ensuring all ordered components meet the exact specifications in the design.
- I coordinate directly with reliable manufacturers (JLCPCB, PCBWay, AllPCB) for quotation, production, and quality checks.

This means you don't need to handle technical discussions with factories, navigate confusing manufacturing options, or worry about compatibility I take care of every step from order placement to delivery.

- I take care of component sourcing from only trusted and reliable suppliers to guarantee quality and compatibility:



- I work with top-rated PCB manufacturers to ensure high-quality production:



- I prepare a complete BOM (Bill of Materials) with correct part numbers, manufacturer details, and sourcing links.
- I handle bulk ordering to reduce costs, speed up production, and ensure you have spare units if needed.
- I personally review and approve Gerber files before manufacturing to prevent costly errors.
- I track the entire manufacturing process to ensure it meets your quality standards and delivery timeline.
- After fabrication, I arrange secure shipping directly to your address, whether local or international.
- You don't need to deal with manufacturers, negotiate prices, or manage logistics — I take care of every complexity so your PCB project is delivered ready to use, within budget, and on time.