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A single measurement chain can enable control, monitoring and analyzing at the same time by ensuring seamless IT and OT connectivity.

WHITE PAPER

digiBOX Industrial Parallel IT/OT Connectivity

From deterministic process signals to high-resolution data streams for Industrial AI and digital twins.

Executive Summary

digiBOX Industrial combines sample-synchronous data acquisition for strain-gauge and piezoelectric sensors with parallel OT and IT interfaces. The amplifier provides selected process values deterministically to PLCs, fieldbus systems and I/O while simultaneously transmitting states, parameters and complete time series to IT applications.

On the IT side, MQTT, openAPI/REST and openDAQ™ serve different roles. MQTT distributes condensed key values and status information. openAPI orchestrates on-demand read, write and action access to the object dictionary. openDAQ transmits the complete measurement stream at up to 40 kS/s per channel.

Quality analysis, traceability, digital twins and AI models can therefore use the same measurement basis as the machine process.

1. Requirements for Digital Amplifiers Beyond Industry 4.0

Industry 4.0 established vertical data exchange between machines, control systems and enterprise IT. However, many implementations remain limited to slowly updated process values and status information. Industrial AI, autonomous manufacturing and digital twins additionally require time-resolved, reproducible sensor data.

The central challenge is balancing determinism and data volume. PLCs require a small number of signals that arrive reliably and predictably. Analytics applications, by contrast, require complete waveforms and the highest possible sampling rates. A modern amplifier platform must meet both requirements in parallel.

Interface	Role	Typical value
Fieldbus/I/O	Control	Deterministic process control and fast response
MQTT	Distribute	Key values, states, events and IoT connectivity
openAPI	Orchestrate	Parameterisation, recipe management and service
openDAQ	Stream	High-resolution analytics, AI and digital twins

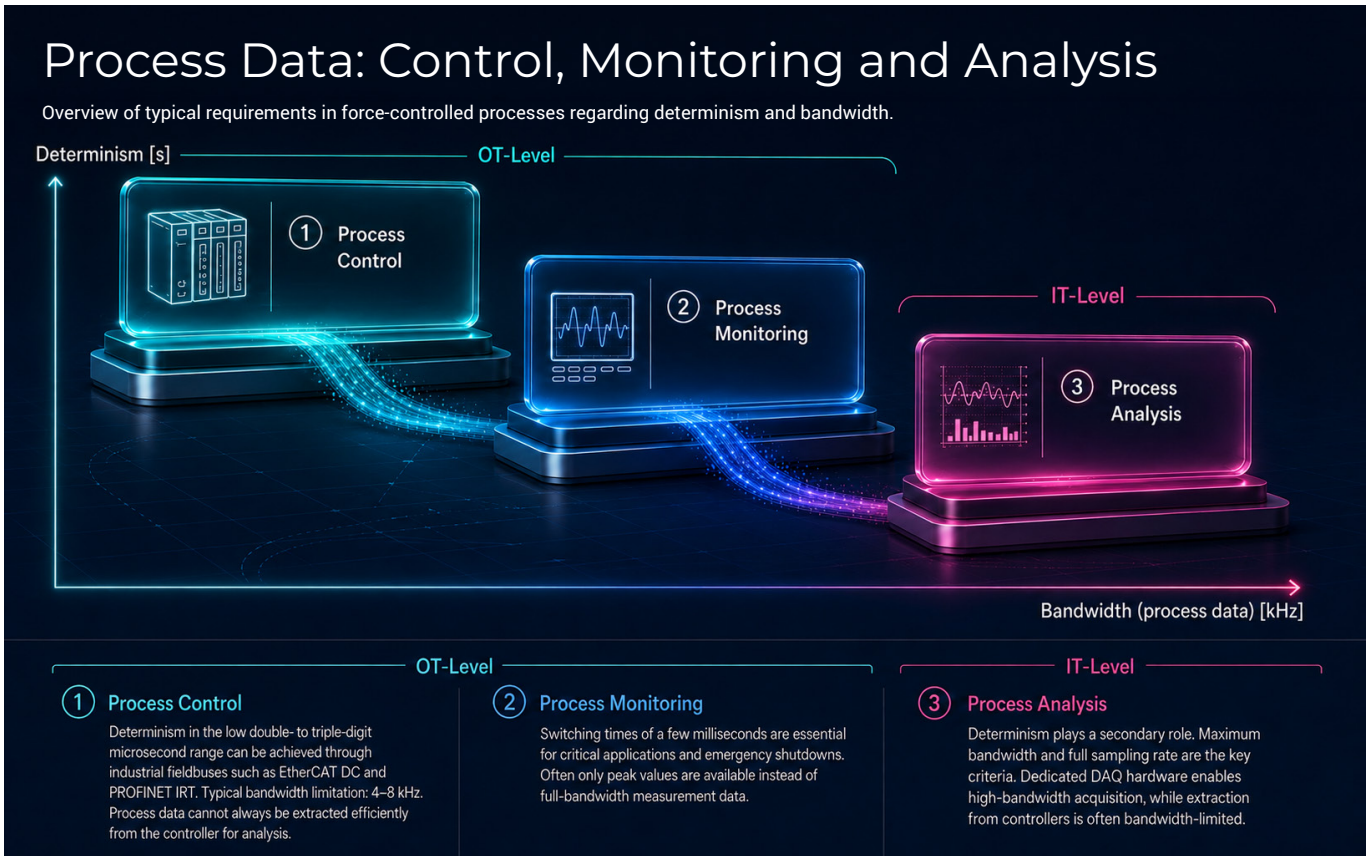

Figure 1: Mapping of requirements for determinism and bandwidth for control, monitoring and analysis applications.

2. Device Concept: Sensors, Edge Processing and Object Dictionary

2.1 Sensor Inputs

Depending on the configuration, digiBOX provides two or four inputs for full-bridge strain-gauge and/or piezoelectric sensors. The channels acquire data sample-synchronously with 24-bit A/D conversion at up to 40 kS/s per channel. Static and dynamic mechanical quantities, including force, weight, torque, pressure and strain, can therefore be captured on a common time base.

2.2 Integrated Signal Processing

Integrated signal processing performs scaling, teach-in, zeroing, two-stage filtering, and statistical or domain-specific calculations. These include maximum, minimum and peak-to-peak values, captured values, limit switching, summing and centre-of-gravity functions. This preprocessing provides each interface with the appropriate level of information.

2.3 Shared Object Dictionary

Measured values, parameters, results, status information and control functions are consistently represented in the object dictionary. Fieldbus, MQTT and openAPI therefore access the same semantic device model. The device-specific dictionary can be exported as a CSV file, supporting traceable integrations.

3. Parallel IT/OT Connectivity

digiBOX provides physically separated interfaces for Industrial Ethernet and TCP/IP-based IT protocols. Measurement data can be supplied simultaneously via fieldbus, analogue outputs, digital I/Os and Ethernet. The PLC remains responsible for the deterministic process control, while IT systems can independently access key values, parameters or high-resolution streams.

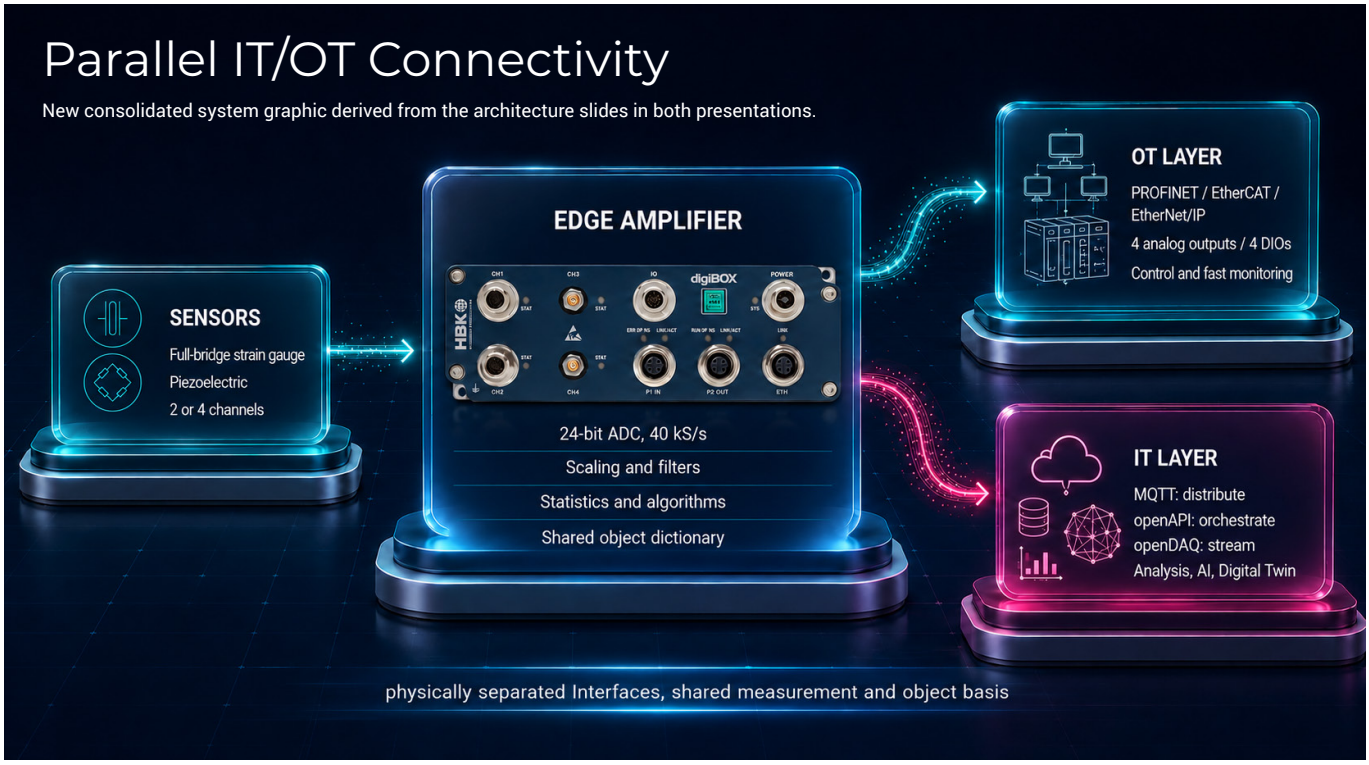

Figure 2: Condensed digiBOX system architecture with sensors, edge processing, and parallel OT and IT connectivity.

Architecture principle: The PLC uses the signals required by the control loop. In parallel, IT applications receive exactly the data resolution required by their use case.

4. MQTT: States, Key Values and IoT Connectivity

digiBOX operates as an MQTT 3.1.1 client and supports TLS 1.2. Up to four objects from the object dictionary can be transmitted cyclically to a broker. The fastest cyclic publishing interval is one second. JSON-RPC additionally enables on-demand read and write access.

- Suitable for transmitting condensed values, device states, quality indicators and events
- Broker address, port, client ID and optional credentials are configured through the web server
- TLS requires a valid time base provided via NTP
- openDAQ is the recommended interface for complete high-speed waveform data

Use Case: Condition Monitoring of a Joining Station

- The PLC executes the joining process via Industrial Ethernet
- digiBOX calculates peaks, limit values and final values locally
- MQTT publishes selected quality and status objects to the broker
- An edge or cloud service identifies trends and detects drift
- If anomalies occur, additional diagnostic values can be read on demand

5. openAPI/REST: Parameterisation and Vertical Integration

The REST interface is described by an openAPI 3.1.0 specification. Applications can read objects from the digiBOX object dictionary on demand and, where permitted, modify them or trigger actions. MES, engineering, service and recipe-management systems can therefore be integrated without manual intervention.

Use Case: Recipe-Controlled Changeover

- The MES assigns a validated parameter set to the next product
- The integration application reads the status and active parameter set
- Approved parameters or the complete parameter set are activated in a controlled manner
- Read-back and plausibility checks confirm the target state
- Only then does the PLC receive production approval

Boundary: openAPI is transactional and on demand. MQTT is more efficient for telemetry, while openDAQ is designed for continuous, high-resolution time series.

6. openDAQ Streaming: High-Resolution Data for Analytics and AI

digiBOX meets openDAQ Compliance Level C and supports device discovery and Streaming LT. Measurement data can be transmitted at up to 40 kS/s per channel. The SDK is available for Windows®, Linux and macOS, and for C++, C# and Python. Device discovery uses mDNS within IPv4 networks.

Use Case: Reference Data Set for AI-Based Quality Assessment

- The PLC controls the process and supplies product and quality context
- In parallel, an edge PC records complete force or strain waveforms
- Waveforms are linked to process phase, recipe, tool condition and quality labels
- Features or models are trained using segmented time series
- Validated inference runs at the edge; the PLC receives only the decision-relevant result

Use Case: Digital Process Twin

openDAQ supplies high-resolution time series, PTP aligns multiple data sources to a common time base, openAPI provides configuration context, and MQTT distributes complementary states and events. Together, these technologies create a consistent data package comprising waveforms, device parameters, equipment state and product context.

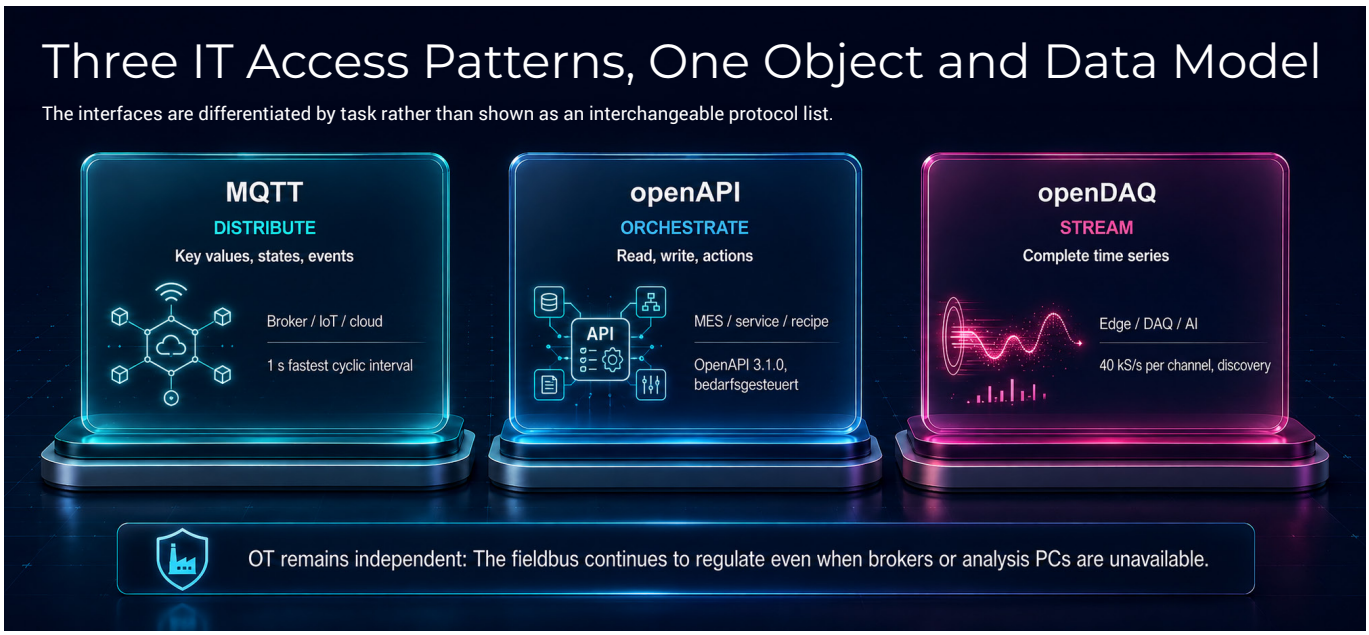

Figure 3: Task-oriented differentiation of the IT protocols MQTT, openAPI and openDAQ

7. End-to-End Interaction

Process phase	OT	MQTT	openAPI	openDAQ
Changeover	Process locked	Status	Check/activate recipe	Optional reference stream
Production	Control	Key values and events	On-demand queries	Waveform recording
Quality	Immediate response	Distribute result	Read diagnostics	Complete waveform
Optimisation	Approved values	Trends and alerts	Deploy parameters	Training data

Rule of thumb: MQTT distributes, openAPI orchestrates, openDAQ streams, and the fieldbus controls.

8. Cybersecurity and Network Architecture

digiBOX supports IPv4 with DHCP, APIPA or static addressing. Only MQTT can be protected using TLS. The web server, openAPI and streaming interfaces do not use HTTPS encryption. The device should therefore operate within a protected automation network. External access should be provided through appropriate firewalls, VPNs or a secured edge layer.

- Segment IT and OT networks and permit only required communication paths
- Operate MQTT with TLS 1.2, individual credentials and a unique client ID
- Restrict and log REST write access, and verify changes through read-back
- Route openDAQ streams only to authorised data recipients
- If the broker or analytics PC fails, the machine process must continue in a defined manner or stop safely

9. Selection Guide and Pilot Implementation

Recommended Pilot Approach

- Define the use case and required time resolution
- Specify OT signals, IT key values and analytics channels separately
- Export the object dictionary and document access rights
- Define the network architecture, DNS, NTP/PTP, ports and responsibilities
- Test failure scenarios and verify safe operating states
- Evaluate the benefits against measurable success criteria

10. Conclusion

digiBOX Industrial evolves the digital amplifier into an edge node, bridging the gap between physical processes, control systems and data-driven value creation. By separating communication tasks, it prevents cloud or analytics demands from dominating critical machine control, whilst making the complete measurement stream fully available for new applications.

The decisive value comes from the coordinated use of all layers: fieldbus and I/O handle real-time control, MQTT distributes data, openAPI orchestrates systems, and openDAQ streams high-precision measurements. A single qualified measurement chain can therefore support process control, quality evidence, diagnostics, digital twins and Industrial AI simultaneously.

Requirement	Preferred access
Deterministic control	Fieldbus/I/O
Few key values for multiple consumers	MQTT
Targeted parameter or action access	openAPI/REST
High-speed waveforms and raw data	openDAQ
Time-correlated data from multiple devices	openDAQ + PTP