HBK
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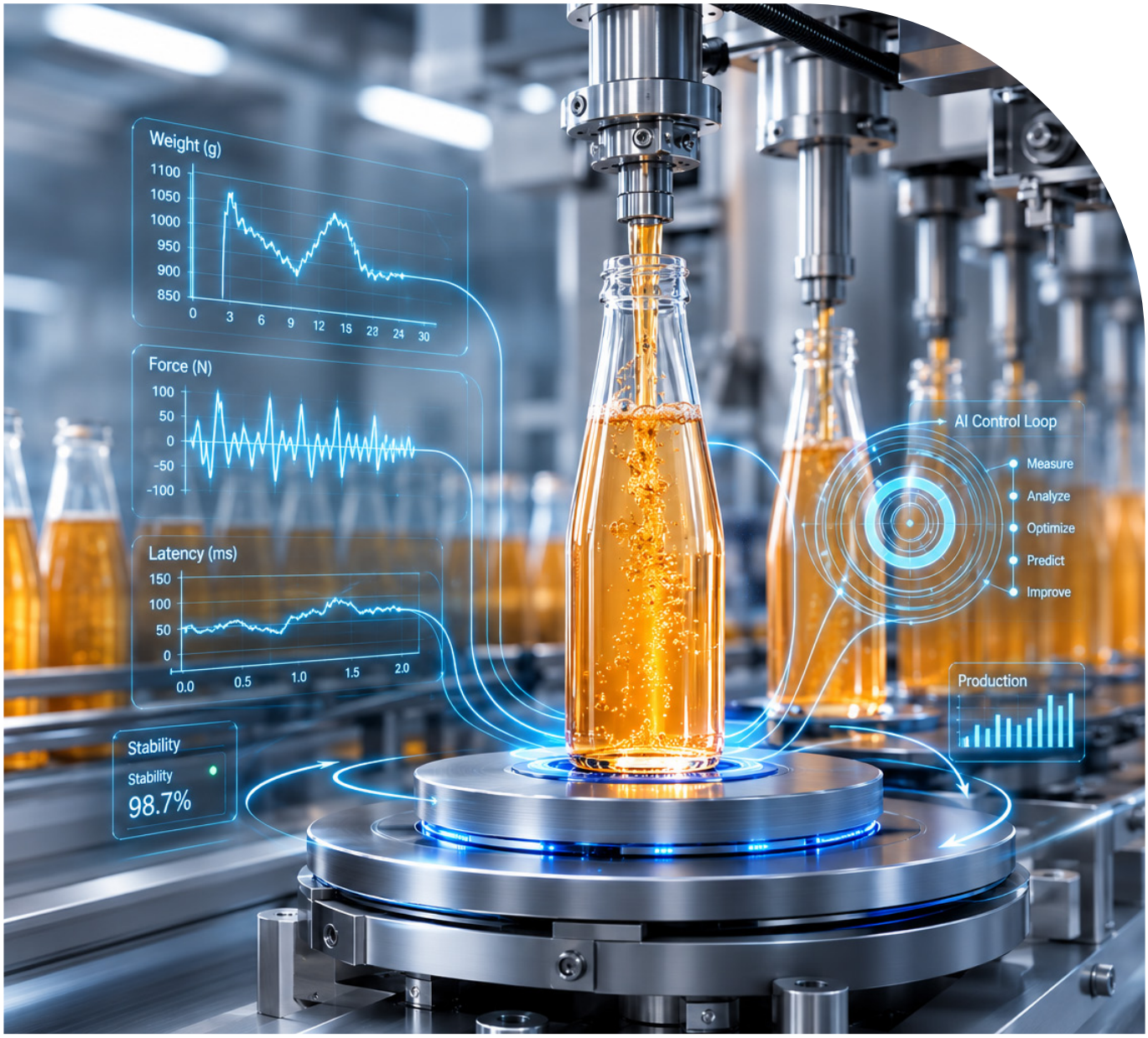



PRECISION WEIGHING & FILLING SOLUTIONS

# Industrial Filling Applications

An engineering guide to stable, fast, and accurate filling.

## Rethinking filling – from weight measurement to real-time process control

In modern production lines, filling is no longer a simple dosing step. It is a critical operation where throughput, accuracy, and compliance must be achieved simultaneously – at every cycle.

Industrial filling applications span a wide range of products and industries, from liquor, soy sauce, vinegar, edible oils, dairy products, and fruit juices to daily chemicals and other high-volume consumer goods. Each introduces specific challenges in terms of flow behaviour, viscosity, foaming, hygiene, and process stability.

As line speeds increase, traditional approaches reach their limits. Variability in product behaviour, machine-induced disturbances, and delayed signal response lead to:

- Product giveaway (typically 0.5% to 2% in high-speed lines)
- Longer cycle times due to stabilisation delays
- Difficulty maintaining consistent process capability (Cp/Cpk ≥ 1.33 – 1.67)

The root cause is not measurement accuracy alone – it is the inability to manage the dynamic behaviour of the filling process.

Filling must therefore be treated as a real-time control system, where weight becomes a control variable within the machine. This enables faster decisions, reduced variability, and improved overall equipment effectiveness (OEE).

Engineering insight: Most filling performance losses are not caused by sensor accuracy – but by delayed or over-filtered signals that prevent timely control decisions.

## Understanding filling dynamics – why most filling systems underperform

During a filling cycle, the weight signal is never stable. It evolves continuously under the influence of multiple physical effects:

- Mechanical vibration from conveyors and actuators introduces oscillations into the weighing structure
- Fluid dynamics (turbulence, foaming, viscosity variation) create transient mass fluctuations
- Bulk material flow leads to irregular and non-linear filling behaviour
- Machine interactions (valves, nozzles, handling systems) generate parasitic forces that distort measurements. These effects are inherent to real production environments – and intensify at higher speeds.

Traditional systems attempt to compensate using signal filtering. While filtering stabilises the signal, it introduces latency – typically 10 to 200 ms. This results in:

- Delayed cut-off decisions
- Increased overfill
- Reduced throughput

The challenge is not to eliminate dynamics, but to measure and react to them in real time.

Engineering insight: Most filling systems are slowed down by their own filtering strategy. Stability is achieved – but at the cost of responsiveness.

## Selection guidelines – choosing the right system approach

Selecting the right solution depends on process requirements:

- High-speed filling = prioritise low latency and fast response
- High-precision dosing = focus on resolution and signal stability
- Harsh or hygienic environments = ensure appropriate protection and materials
- Flexible/connected systems = use digital communication (for example, IO-Link)

The correct choice is defined by the system's ability to support process performance, not by individual component specifications.

## Architecture first

Selecting the right solution depends on process requirements:

| Integrated (Digital Load Cells) | Modular (Load Cell + Electronics) |
|---|---|
| • Fast integration, minimal wiring<br>• Fixed, validated signal chain<br>• Ideal for standardised OEM machines | • Maximum flexibility<br>• Tuned for speed, accuracy, or environment<br>• Ideal for high-performance or custom machines |

## Filling system architecture – from measurement chain to control loop

Achieving stable and high-speed filling requires a fully aligned system architecture – from mechanical integration through to control logic.

**Measurement chain**

A typical system includes:

- Mechanical structure: defines how forces are transmitted
- Load cell: converts force into an electrical signal
- Signal conditioning: amplification and digitisation
- Signal processing: real-time evaluation
- PLC/control system: decision-making and actuation
- Data layer: integration into SCADA/MES/IT systems

Each layer directly impacts performance. Weakness in one element cannot be compensated for elsewhere

**Measurement accuracy starts at the sensing element**

At the core of this chain lies the sensor itself. HBK's expertise in strain gauge technology, sensor design, and in-house production ensures:

- High signal fidelity under dynamic conditions
- Long-term stability and repeatability
- Consistent performance across industrial environments.

This foundation is critical for achieving reliable behaviour in high-speed, dynamic filling applications.

Engineering insight: Dynamic performance is defined at the sensor level – long before signal processing or control logic.

**Closed-loop control in filling**

Modern filling systems rely on real-time closed-loop control:

1. Continuous weight acquisition
2. Real-time evaluation of the filling state
3. Dynamic adjustment (valve/flow control)
4. Precise cut-off at target weight

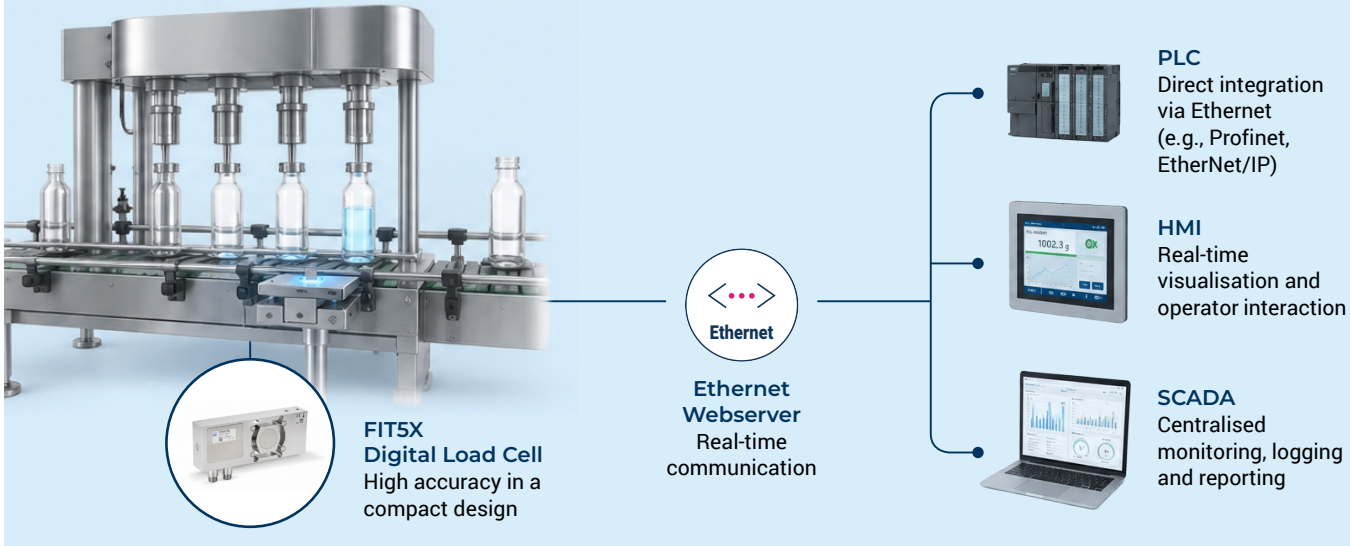
**Typical control sequence:**

- Coarse fill = high speed
- Fine fill = controlled approach
- Cut-off = precise stop

Performance depends on how quickly and accurately the system can react within this sequence.

Engineering insight: The precision of the cut-off is directly linked to signal latency – not just measurement accuracy.

### Integrated Filling Architecture



## Process optimisation levers – where measurable performance gains are achieved

- **Reducing product giveaway**
  Precise, real-time cut-off control reduces overfill.
  A reduction of 0.2 – 0.5% giveaway can represent significant annual savings in high-volume production.
- **Minimising settling time**
  Faster signal response reduces waiting time before decision-making. Typical gains: 100 – 300 ms per cycle, directly increasing throughput.
- **Increasing throughput**
  Higher responsiveness enables faster machine operation without sacrificing accuracy.
- **Improving repeatability**
  Stable measurement and control improve process capability (Cp/Cpk), ensuring compliance and consistent product quality.

Engineering insight: Throughput is not only a function of machine speed – but of how quickly the system can trust its own measurement.

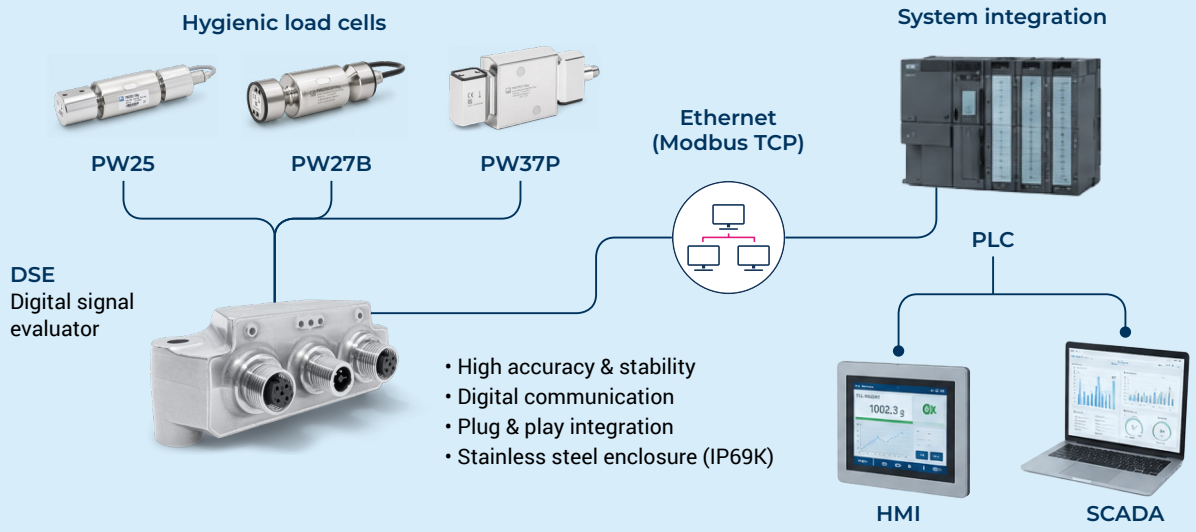
## Integration best practices – designing for performance, not just functionality

- **Mechanical integration**
  - Ensure high structural stiffness
  - Avoid side loads and parasitic forces
  - Optimise load introduction
- **Environmental control**
  - Manage vibration sources
  - Consider thermal effects
  - Select the appropriate protection level
- **Compliance and hygienic design**
  - In regulated and hygienic environments, performance must be maintained under real operating conditions:
    - OIML-certified load cells ensure compliance for legal-for-trade applications across the measurement chain
    - EHEDG-certified designs (for example, PW27, PW37, DSE) support hygienic operation with high resistance to cleaning processes (IP69K)
- **Signal integrity**
  - Minimise electrical noise
  - Signal architecture (analogue/digital)
  - Avoid excessive filtering

Well-executed integration can improve measurement stability by up to 50%, with a direct impact on control performance.

Engineering insight: Compliance is more than certification – it ensures real-world performance. Mechanical design is often the hidden limiter of filling performance.

## Hygienic Modular Architecture



## Digitalisation and smart filling – from measurement to adaptive performance

Filling systems are increasingly connected and data-driven. Key enablers include:

- IO-Link for simplified integration, diagnostics, and parameterisation
- Edge processing solutions such as digiBOX Weighing for real-time data handling
- Open communication protocols (MQTT, open architectures) for IT/OT convergence
- Bus interfaces including CAN, DeviceNet, ProfiNET, and EtherNet/IP for reliable industrial communication and device connectivity

**Advanced system capabilities**

Modern systems enable adaptive performance through:

- Self-optimisation: automatic parameter adjustment under changing conditions
- System error compensation: real-time correction of mechanical and environmental deviations
- Dynamic signal visualisation: real-time access to process behaviour for tuning and diagnostics

These capabilities enable:

- Real-time monitoring of process behaviour
- Faster commissioning and setup
- Predictive diagnostics
- Continuous performance optimisation

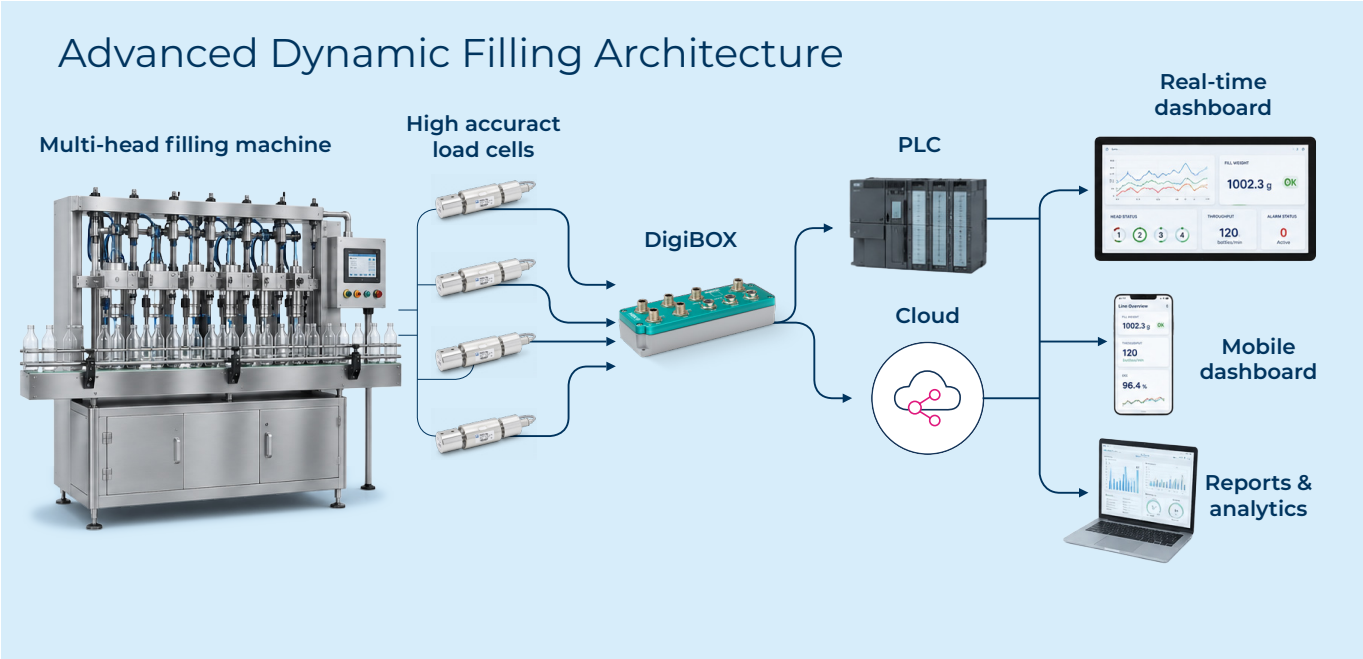
Engineering insight: Digitalisation is not about connectivity – it is about making faster, better control decisions. The ability to visualise dynamic behaviour is often the fastest way to improve filling performance.

## Key takeaway

High-performance filling is achieved when mechanics, measurement, and control are fully aligned. By transforming weighing into a real-time control variable, manufacturers can:

- Increase throughput
- Reduce material loss
- Stabilise process performance
- Ensure consistent product quality

Filling is no longer a constraint – it becomes a lever for industrial performance.



# Digital Load Cells

## Integrated digital load cells

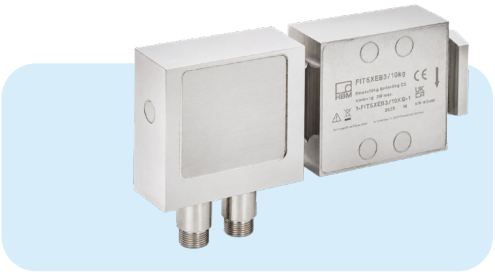
### FIT5X – Connected digital load cell for smart filling architectures

**Key features:**

- Capacity range: 5 kg to 20 kg
- Integrated Ethernet and webserver
- Protection class: IP68

**Key advantages:**

- Fast integration into PLC and IT systems
- Remote diagnostics and parameterisation
- Improved machine connectivity
- Communication protocol : PROFINET, EtherNet/IP, EtherCAT, Modbus TCP, CANopen, DeviceNet, RS485



### FIT5A – Compact digital weighing for standardised filling systems

**Key features:**

- Capacity range: 5 kg to 50 kg
- Accuracy class: up to C3
- Protection class: IP68/IP69K

**Key advantages:**

- Simplified integration and wiring
- Stable and reliable digital signal
- Reduced commissioning effort

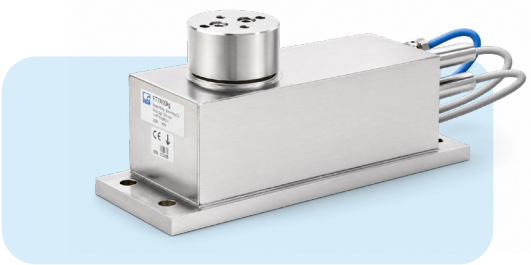
### FIT7A – High-performance digital weighing for dynamic applications

**Key features:**

- High-resolution digital output
- Fast response for dynamic weighing
- Industrial protection class: IP67

**Key advantages:**

- Optimised for high-speed filling
- Stable performance under dynamic conditions
- Improved process repeatability



## Digital integration solutions

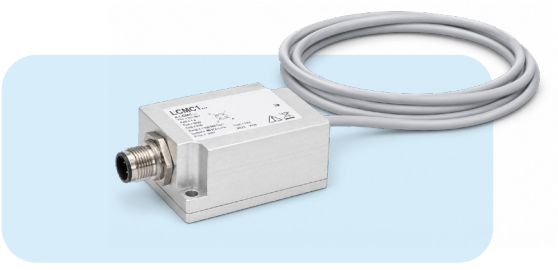
### LCMC – Flexible digital weighing architecture for industrial automation

**Key features:**

- Modular analogue, digital, and IO-Link configurations
- Industrial communication compatibility
- Designed for load cell and electronics integration

**Key advantages:**

- Flexible adaptation to machine architectures
- Simplified integration into automation systems
- Supports scalable and connected weighing solutions



| Digital load cells | | | FIT5A | FIT5X | FIT7A |
|---|---|---|---|---|---|
| **Interface** | | | RS 485, CANopen, DeviceNet | RS 485, CANopen, DeviceNet, PROFINET, Ethernet/IP EtherCAT, Modbus | RS 485, CANopen, DeviceNet |
| **A/D conversion** | bit | | 24 | | |
| **Sample rate** | S/s | | 4 ... 1200 | Up to 2000 (ethernet version) | 4 ... 1200 |
| **Weighing functions** | | | Checkweigher, filling and dosing | | |
| **Quantity of digital input / output** | | | Up to 6 | | |
| **Maximum capacity** | $E_{max}$ | kg | 5 ... 50 | 5 ... 20 | 3 ... 75 |
| **Accuracy class** | | | C3 | C3 | C3, C4, C6 |
| **Maximum platform size** | | mm | 400 x 400 | 400 x 400 | 400 x 400 (Emax 3 - 20kg), 600 x 500 (Emax 30 - 75kg) |
| **Nominal (rated) sensitivity** | $C_n$ | digit | 1 000 000 | | |
| **Zero signal** | | | 0 ±100 000 | | |
| **Temperature effect on sensitivity Temperature range: +20 ... +40°C -10 ... +20°C** | $TC_S$ | % of $C_n$/ 10 K | ±0.0218<br>±0.0150 | ±0.0200<br>±0.0133 | |
| **Temperature coefficient of zero signal** | $TK_0$ | | ±0.0160<br>Up to ±0.008 | ±0.0160 | ±0.0160 Up to ±0.008 |
| **Hysteresis error** | $d_{hy}$ | % of $C_n$ | ±0.0166 | | |
| **Non linearity** | $d_{lip}$ | | ±0.0166 | | |
| **Minimum dead load output return** | MDLOR | | ±0.0166 | | |
| **Off center load error** | | | ±0.0166 | ±0.0233 | |
| **Nominal temperature range** | BT | °C | -10 ... +40 | | |
| **Service temperature range** | $B_{tu}$ | | -10 ... +50 | | |
| **Storage temperature range** | $B_{tl}$ | | -25 ... +70 | | |
| **Limit load at 20 mm eccentricity** | $E_L$ | % of $E_{max}$ | 1000 | | |
| **Service load at max. 120 mm eccentricity** | $E_U$ | | 150 | | |
| **Relative permissible oscillation stress at max.** | $F_{srel}$ | | 70 | | |
| **Deflect. at $E_{max}$, approx.** | $s_{nom}$ | mm | < 0.2 | < 0.2 | < 0.1 |
| **Weight, approx.** | m | kg | 1.6 | 1.6 | 3 |
| **Protection class** | | | IP 68 (test conditions 100 h at 1 m water column);IP69K (water at high pressure, steam jet cleaning) | | IP66 |
| **Measuring body material** | | | Stainless steel 1.4545 | | Housing: Stainless steel 1.4545<br>Baseplate: Stainless steel 1.4301 |
| **Certificate** | | | ECOLAB | ECOLAB | ECOLAB |

# Analog Load Cells

## Single point load cells

### PW25 – Dynamic weighing for fast filling processes

**Key features:**

- Capacity range: 10 kg to 20 kg
- Accuracy class: up to C3MR
- Optimised for dynamic applications

**Key advantages:**

- Reduced settling time
- Stable dynamic performance
- Optimised for fast filling cycles

### PW37P – Premium hygienic weighing for demanding production environments

**Key features:**

- Capacity range: 50 kg to 200 kg
- Accuracy class: up to C3MR
- EHEDG certified, IP68/IP69K

**Key advantages:**

- Resistant to aggressive cleaning processes
- Excellent long-term stability
- Ideal for food, beverage, and pharma filling

## Hygienic and high-performance load cells

### PW27B – Hygienic weighing standard for food and filling applications

**Key features:**

- Capacity range: 10 kg to 20 kg
- Accuracy class: up to C3
- EHEDG certified, IP68/IP69K

**Key advantages:**

- Optimised for washdown environments
- Stable under dynamic filling conditions
- Long-term hygienic reliability

### PW15AH/PH – High-performance industrial weighing for fast machine cycles

**Key features:**

- Capacity range: 10 kg to 75 kg
- Accuracy class: up to C3MR
- Stainless-steel design, IP68/IP69K

**Key advantages:**

- Excellent dynamic behaviour
- Reduced response time
- Suitable for high-speed filling systems

| Analog load cells | | | PW15AH | PW25 | PW27B | PW37P |
|---|---|---|---|---|---|---|
| **Maximum capacity** | $E_{max}$ | kg | 10...100 | 10...20 | 10...20 | 50...200 |
| **Accuracy class** | | | C3 MR, C6 MR | C3 MR | C3 MR | C3 MR |
| **Maximum platform size** | | mm | 500 x 400 | 400 x 400 | 400 x 400 | 600 x 600 |
| **Sensitivity** | $C_n$ | mV/V | 2.0±0.2 | | | |
| **Zero balance** | | mV/V | 0 ±0.1 | | | 0 ±0.2 |
| **Temperature effect on sensitivity**<br>**Temperature range:**<br>**+20 ... +40°C [+68 ... +104°F]**<br>**-10 ... +20°C [+14 ... +68°F]** | $TK_C$ | % of $C_n$/ 10 K | ±0.0175<br>±0.0117 | | | |
| **Temperature coefficient of zero signal** | $TK_0$ | | ±0.0140 Up to ±0.0056 | ±0.0140 | ±0.0140 | ±0.0140 Up to ±0.0056 |
| **Hysteresis error** | $d_{hy}$ | % of $C_n$ | ±0.0166 | | | |
| **Non-linearity** | $d_{lin}$ | | ±0.0166 | | | |
| **Minimum dead load output return** | MDLOR | | ±0.0166 | | | |
| **Off center load error** | | | ±0.0233 | | | |
| **Input resistance** | $R_{LC}$ | Ω | 300 ... 500 | | | 380 ±15 |
| **Output resistance** | $R_0$ | | 300 ... 500 | | | 360 ±10 |
| **Reference excitation voltage** | $U_{ref}$ | V | 5 | | | |
| **Nom. range of excitation voltage** | $B_U$ | | 1 ... 12 | | | |
| **Max. excitation voltage** | | | 15 | | | |
| **Insulation resistance with 100 VDC** | Ris | GΩ | > 1 | | | > 2 |
| **Nominal temperature range** | $B_T$ | °C | -10 ... +40 | | | |
| **Service temperature range** | $B_{tu}$ | | -10 ... +50 | | -20 ... +70 | |
| **Storage temperature range** | $B_{tl}$ | | -25 ... +70 | | -25 ... +90 | |
| **Limit load at 20 mm eccentricity** | $E_L$ | % of $E_{max}$ | 150 (at 160mm eccentricity) | 1000 | 1000 | 150 |
| **Lateral load limit, static** | $E_{lq}$ | | 300 | 200 | 200 | 150 |
| **Service load at max. 100 mm eccentricity** | $E_U$ | | 150 | | | |
| **Breaking load at max. 20 mm eccentricity** | $E_d$ | | 300 | >1000 | >1000 | >300 |
| **Relative permissible oscillation stress at max.** | $F_{srel}$ | | 70 | | | |
| **Deflect. at $E_{max}$, approx.** | $S_{nom}$ | mm | < 0.5 | 0.19 | < 0.19 | < 0.17 |
| **Weight, approx.** | m | kg | 1.0 | 0.8 | 0.8 | 1.2 |
| **Protection class** | | | IP 68 (test conditions 100 h at 1 m water column); IP69K (water at high pressure, steam jet cleaning) | | | |
| **Measuring body material** | | | Stainless steel 1.4545 | | | |
| **Certificate** | | | ECOLAB | ECOLAB | ECOLAB EHEDG | ECOLAB EHEDG |

## Weighing electronics

### PAD – Compact weighing electronics for reliable signal conditioning

**Key features:**

- Fast analogue/digital signal processing
- Compact DIN-rail format
- Industrial communication support

**Key advantages:**

- Simplified installation
- Stable signal transmission
- Cost-efficient machine integration

### DSE – Advanced weighing controller for industrial automation

**Key features:**

- High-speed processing cycle
- Ethernet connectivity webserver
- Hygienic version available

**Key advantages:**

- Precise real-time control
- Fast integration into automation systems
- Suitable for hygienic applications

### DigiBOX Weighing – Edge process optimisation

**Key features:**

- Real-time low-latency processing
- Integrated Ethernet and fieldbus connectivity
- Dynamic signal visualisation tools

**Key advantages:**

- Reduced latency for fast control loops
- Supports system self-optimisation
- Improved process diagnostics and tuning

| Weighing electronics | | PAD | DSE | digiBOX |
|---|---|---|---|---|
| **Interface** | | CANopen or RS485 (4-wire, fullduplex) | PROFINET, EtherCAT, Modbus | PROFINET® ,openDAQ, MQTT, OPENAPI (RestAPI) |
| **Number of channels** | | 1 | 1 | 2 or 4 |
| **Maximum number of calibration values as per OIML R76 (Class III, IIII)** | d = e | 6000 | 1000 | |
| **A/D conversion** | bit | 24 | | |
| **Sample rate** | S/s | 4 … 1200 | 2000 | 2000 |
| **Weighing functions** | | Checkweigher, filling and dosing | | |
| **Quantity of digital input / output** | | 2 | – | 4 or 8 |
| **Transducer impedance** | Ω | 300 … 1200 | 200 … 4500 | 80 … 5000 |
| **Measuring range** | mV/V | nominal ±2; max. ±3.2 | nominal ±2; max. ±4 | nominal ±2; max. ±5 |
| **Transducer excitation voltage** | V | 5 $V_{AC}$ (carrier frequency 1.2 kHz) | 5 ± 5 % | 5 ± 5 % |
| **Non-linearity** | % | ±0.0025 | ±0.0025 | ±0.005 |
| **Zero Signal Temp. Coeff. / 10 K** | % | ±0.0055 | ±0.0025 | ±0.005 |
| **Sensitivity Temp. Coeff. / 10 K** | % | ±0.0083 | ±0.0025 | ±0.005 |
| **Operating temperature range** | °C | -10 … +50 | -10 … +50 | -20 … 65 |
| **Storage temperature range** | °C | -25 … +75 | -25 … +75 | -40 … 85 |
| **Allowed relative humidity** | % | 10 … 90 | 10 … 70 | 5 … 95 |
| **Degree of protection per EN 60529 (IEC529)** | | IP68/69K | IP67 / IP68 / IP69K | IP67 |
| **Certificate** | | | ECOLAB EHEDG | |

## Software, connectivity and integration ecosystem

**panelX – Intuitive software for commissioning, visualization and diagnostics**

Key benefits
- Intuitive visual interface
- Real-time signal visualization
- Simplified commissioning
- Diagnostic functions
- Faster process optimization
- Easy parameter management and data analysis

**Integrated Web Interface - Visualize, configure and analyze devices from any web browser**

Key benefits
- No software installation required
- Access from any standard web browser
- PC, tablet and smartphone compatibility
- Local and remote configuration
- Real-time process monitoring
- Faster troubleshooting and maintenance

**Industrial Cable Solutions – Reliable connectivity for robust filling machine integration**

Available solutions
- L-type cables / Y-type cables
- High-protection cable versions

Key benefits
- Effortless on-site connection
- Stable signal transmission
- Reduced installation effort
- Improved machine reliability
- Extended sensor service life

**Communication Protocols - Flexible connectivity for industrial automation systems**

Key features
- Industrial Ethernet and fieldbus support
- PLC, SCADA and IT/OT integration
- Real-time digital communication

Key advantages
- Simplified machine integration
- Reliable data exchange across systems
- Faster commissioning and diagnostics

## Product selection matrix: Choose the right filling solution

| Solution | Typical Application | Certifications | Connectivity | Capabilities |
|---|---|---|---|---|
| FIT5A | Compact OEM filling machines | OIML | Digital communication | Compact integration, fast commissioning |
| FIT5X | Connected filling systems | OIML | Ethernet, webserver | Real-time communication, remote diagnostics |
| FIT7A | High-speed filling | OIML | Digital communication | Fast response, dynamic weighing |
| PW15AH/PW25/ PW27B/PW37P + digiBOX Weighing | High-speed and dynamic filling | OIML | Ethernet, MQTT, webserver | Real-time processing, edge analytics, reduced latency |
| PW25/PW27B/ PW37P + DSE | Hygienic food and beverage filling | OIML, EHEDG, IP69K | Ethernet, webserver | Hygienic design, stable process control |
| SP4Mi | Smart connected filling machines | OIML, IP67 | IO-Link | Smart sensor integration, remote parameterisation, simplified wiring |
| PW15AH/PW25/ PW27B/PW37P + LCMC | Flexible modular filling architectures | OIML | IO-Link, CANopen, RS-485, Analogue | Modular configuration, scalable integration, connected weighing architecture |

## Weighing 4.0 by HBK

Industrial filling systems are evolving rapidly. Production lines are becoming faster, more flexible, and increasingly connected. At the same time, demands for accuracy, repeatability, and traceability continue to increase, while reducing product giveaway, improving energy efficiency, and maximising OEE have become critical priorities for machine builders and end users alike.

In this environment, weighing can no longer be treated as a stand-alone measurement function. It has become an active part of process control, directly influencing machine stability, throughput, and overall production performance.

HBK (Hottinger Brüel & Kjær) builds on the technological heritage of HBM (Hottinger Baldwin Messtechnik), recognised for decades for its expertise in strain gauge technology, weighing sensors, and high-precision measurement systems.

Today, this expertise extends far beyond the sensor itself. HBK develops complete weighing and control architectures combining sensors, weighing electronics, real-time signal processing, industrial connectivity, and dynamic analysis capabilities.

This approach enables OEMs, system integrators, and manufacturers to:

- Improve filling machine stability and repeatability
- Reduce settling times and product giveaway
- Simplify integration into modern automation architectures
- Leverage weighing data as a true real-time process control variable

From hygienic production environments to high-speed filling lines, HBK supports the transition toward smarter, more responsive, and increasingly data-driven filling systems.

Because today, machine performance is no longer defined by mechanics alone but by the ability to measure, interpret, and react to real physical process behaviour in real time.

HBK – Measurement becomes process intelligence.

### CONTACT US

### ACCELERATE YOUR PRODUCT INNOVATION

HBK provides integrated solutions and domain expertise across the test and measurement product life cycle, bridging the gap between the physical world of sensors, testing and measurement and the digital world of simulation, modelling software and analysis.

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