

IO-Link vs 4-20 mA vs HART — Sensor Signal Comparison

cBallast · IEC 61131-9 / HART 7 / NAMUR NE 43

Three methods at a glance

Method	Layer	Cable	Max length	Diagnostics
4-20 mA loop	Analogue only	Twisted pair shielded	~1000 m	Loop break + NE 43 fault ranges
HART on 4-20 mA	Analogue + digital FSK 1200 baud	Twisted pair shielded	~1500 m	Digital vars, identity, diagnostics
IO-Link IEC 61131-9	Digital point-to-point	Unshielded 3-wire M12	20 m	Full parameterisation, event codes, cyclic + acyclic

4-20 mA loop

Industry workhorse since 1970s. 2-wire transmitter draws 4-20 mA proportional to PV. NAMUR NE 43 failure ranges: 3.6 mA = under/fail low, 21 mA = over/fail high, 3.8-20.5 mA = valid. DCS distinguishes genuine 0% from broken sensor. Simple, well-understood, works with any DCS.

HART

Superimposes 1200-baud FSK modem on 4-20 mA loop without affecting analogue. Handheld communicator or DCS multiplexer queries: multi-PV, calibration, event log, identity, diagnostics. Core analogue loop still works if HART modem fails. HART 7 (2007) added wireless HART (802.15.4 mesh, IEC 62591).

IO-Link

Digital on unshielded 3-wire M8/M12 — same connectors as legacy 24 VDC discrete. One IO-Link master port supports one device ("d 20 m). Master aggregates 8 ports, uplinks to PLC via PROFINET, EtherNet/IP, EtherCAT, CC-Link IE. Same cable + connector carries PV, parameters, event codes, vendor diagnostics. No A/D loss, no calibration drift, no separate cable for OK signal.

Hazardous area

Method	Ex protection	Notes
4-20 mA	Ex ia (galvanic isolator / zener barrier)	Well-established
HART	Ex ia; passes through most barriers	Some older isolators strip HART
IO-Link	Not IS at cell level	Master in safe area, IS sensor + isolator

When to pick which

4-20 mA: existing analog input cards, no extended diagnostics needed, hazardous-area IS. HART: same cabling but want extended diagnostics/calibration monitoring/partial-stroke test — ideal retrofit. IO-Link: greenfield, factory automation with many discrete sensors, machine builders wanting swap-and-configure. Every major PLC OEM has native IO-Link masters (Siemens ET 200, Rockwell POINT I/O, Beckhoff EL6224, Turck TBEN).

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