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Bridging legacy 4-20mA temperature loops

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Sergio Magana discusses how engineers can bring their ageing instrumentation layer into the digital age.



Go into the instrumentation cabinet of almost any European process plant built before the 2000s and you are likely to find the same thing – miles of twisted-pair cables, terminal blocks worn shiny from decades of maintenance visits, and temperature transmitters quietly turning RTD and thermocouple readings into a plain 4-20mA current loop. None of it looks impressive, but most of it still works exactly as it did 30 or 40 years ago.

The challenge however, isn't really about whether that infrastructure still does its job, its whether it is able to keep up with what plants are now being asked to do with their data.

Modern control philosophy runs on data, not just the process value itself, but the health, diagnostics and configuration history behind it. Predictive maintenance programmes, energy optimisation projects and Industry 4.0 pilots, all assume a level of instrument-level visibility that a bare current loop was not built to provide. A 4-20mA signal can tell the PLC what the temperature is right now but cannot provide data about sensor drift, wiring faults, or when the device was last calibrated.

The instrumentation layer is usually the oldest part of the control system, and yet it is this layer that every digitalisation strategy leans on for trustworthy source data. While tearing it all out and starting over sounds clean on paper, in reality it rarely is. The capital outlay, shutdown time, and disruption to processes all push full replacement to the bottom of the list.

It's easy to frame this as a straight choice – keep the analogue wiring as is or swap it all out for

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fieldbus or wireless. Most plants don't treat it that way, and continuous-process operators for chemicals, refining, pulp and paper have particularly good reasons not to.

Analogue loops are still useful. They're simple, they're robust, maintenance crews understand them without training, and they don't introduce the cybersecurity questions that come with adding network-connected devices to a control environment. A lot of safety loops are validated in their current analogue form, and revalidating a fully digital replacement is its own lengthy, expensive project.

The route more plants take is to squeeze more out of what's already installed. Most temperature transmitters put in over the last 20 years already support HART, which adds digital communication to the existing 4–20mA signal using the same field wiring, without disrupting the analogue loop. The current signal keeps doing exactly what it always did. HART just tags along, carrying additional process variables, diagnostic, maintenance, and configuration data the control system has never seen.

Wasted data

This is where a surprising amount of plant data goes to waste. HART-capable transmitters typically hold several measurements and diagnostic parameters beyond the single value that reaches the control room over the loop – flowmeter health, differential pressure, process temperature, electronics temperature, volumetric flow, and a totalizer value. In many plants, none of it has ever been looked at, simply because the I/O card was only ever wired to read the analogue signal and nothing else.

Getting at that data doesn't mean rewiring anything. HART multiplexers and interface modules tap into the existing loop and pull the digital signal off it without interrupting the process, feeding it to asset management software, a historian, or a condition-monitoring platform running alongside the existing control system. For engineering teams trying to show progress on digitalisation without a capital project behind them, this tends to be the easiest place to start. The transmitters are already capable, but they have never been asked.

Falling short

This isn't a substitute for real modernisation, and it's worth saying plainly where it falls short. HART's data rate is slow, and it was never meant for the high-speed, deterministic communication some advanced control or safety applications now need. Retrofitted diagnostics are also only as good as the device sitting in the field. An older transmitter without HART gives you nothing to extract, and some early 'HART-compatible' devices only support a thin slice of what the protocol can do.

There's a people problem too, and it's the one that catches plants out more often than the technical limits. Pulling HART data off a loop is straightforward engineering. Doing something useful with it is not.

Sites that buy the interface hardware without also sorting out the asset management software, the alarm rationalisation, and someone whose job it is to actually look at the data end up with a system quietly generating information nobody reads. The wiring problem gets solved. The organisational problem doesn't.

There is also a cost dimension. Interface hardware and the software to make sense of what it produces are not free, and it competes for budget against every other project on a plant's list. The case for it usually must be made loop-by-loop, not as an abstract digitalisation initiative pointing to a specific unit with a history of unexplained trips, or a process area where energy costs make even a small improvement in temperature accuracy worth chasing. Abstract arguments about "unlocking data" rarely survive a capital approval meeting. A concrete maintenance or efficiency problem usually does.

For engineers weighing this up, it will rarely be just a decision that is made once. Often, it's a series of small decisions that fit around normal maintenance and turnaround schedules. Working out which transmitters already support HART costs nothing beyond an inventory check. From there, interface hardware gets added a loop at a time, prioritising whatever measurements matter most for reliability or energy performance.

Fieldbus or a full digital rebuild is still the right call in some cases with new builds, major revamps, anywhere the analogue wiring has genuinely reached the end of its life. But for the still enormous installed base of working 4-20mA loops, the more common route is evolutionary – leave the



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analogue backbone alone and use the digital layer that's already sitting inside the loop to close the visibility gap.

Most plants already have more capability than their control system currently uses. Before signing off on a big replacement programme, it could be worth finding out exactly how much of that is sitting idle and what it would actually take to switch it on.

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