smart Communication Technology

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Digital data via analog signal forms

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ACDC – a complementary alternative to HART for existing wiring

It is a contradiction of sorts; most field devices on the ends of 4-20 mA current loops have become so smart that the transmission systems connecting them cannot handle the additional information.

In a world in which economic success increasingly depends on data-driven process optimization and process automation, not being able to access all necessary information is no longer an option.

However, to rip and replace an existing and functioning infrastructure, just to achieve the necessary bandwidth for data transmission, makes neither economic nor ecological sense.

Round about 95 percent of the gas detection systems installed in industry plants, communicate on the “last mile” via 4-20 mA systems. The connection between controllers and transmitters is still analog, while the data exchange with other components of the infrastructure is done digitally.

For more than three decades, the means of choice to solve this problem has been the HART communication protocol (Highway Addressable Remote Transducer). It continues to be the best option for all those applications that benefit from an individual composition of components from the list of more than 1,500 registered products. However, for less complex requirements, such as the simple transmission of additional transmitter data, HART is usually too sophisticated.

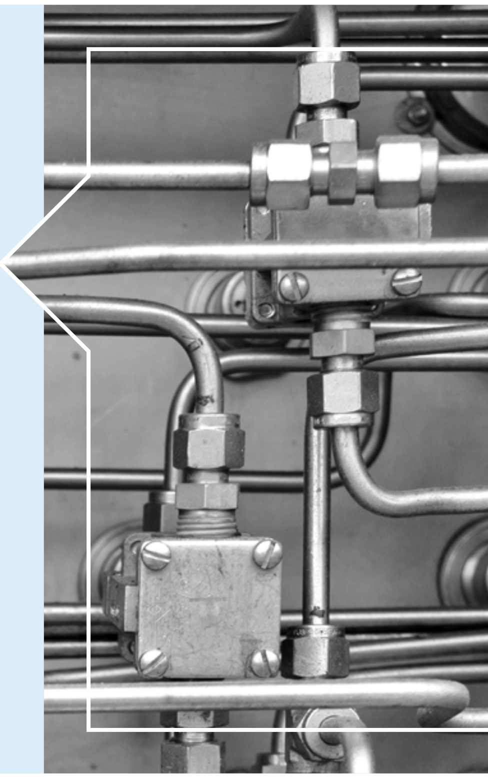
One has to keep in mind that gas detection systems consist of finely tuned and tested components. Although it may occasionally be necessary to integrate a third-party pressure or temperature sensor into a solution if the manufacturer does not offer one, it makes no sense at all to put together such a complex solution using transmitters and controllers from several vendors.

Thus, the real challenge – to transmit digital data quickly and cost-effectively via analog 4-20 mA lines – is unsolved even with HART. It is time for a new approach. It’s time for an Analog Carrier for Digital Communication.

What was the reason for 4-20 mA in the first place?

1) The forerunners of electronic instruments were pneumatic solutions that worked on the principle of the baffle nozzle. 3-15 psi with a ratio of 1:5 was chosen as it is the most linear part on the curve for the movement of the baffle and the resulting back pressure in the nozzle.
2) An intermediate step had been 10-50 mA devices. The first analog electronic instruments used magnetic amplifiers. 10 mA offset zero (then called live zero) was chosen as this is the lowest value at which instruments based on magnetic amplifiers could operate. While maintaining the ratio of 1:5, 10-50 mA was selected as the signal.
3) With the introduction of the transistor, it became possible to develop devices that required less current. Since semiconductor devices require 3 mA current to operate, the new standard had to be above 3 mA.

The exact reasons that led to the choice of 4-20 mA are unfortunately lost. It was likely a combination of a desire to work with integer values, to consume as little power as possible, and the tendency to maintain the familiar 1:5 ratio. Only 4-20 mA or 5-25 mA were practical, and with multiples of 2 it is simply easier to calculate.



Why use a 4-20 mA solution these days anyway?

If data and information ultimately have to be available in digital form in order to be processed, why not transmit them digitally?

For every task in the field of gas detection, devices with analog and digital interfaces are available. GfG customers can choose between 4-20 mA and Modbus/RTU versions for almost all transmitters.

Even faster communication would offer solutions that rely on Industrial Ethernet and allow data transmission in almost real time.

However, such transmission speeds >10 Mbit/s are not necessary at all for gas detection systems whose T90 reaction times are in the one- to three-digit second range, depending on the gas to be monitored.

A glance at history shows that there were a number of good reasons why 4-20 mA solutions became the industry standard (ISA SP50, originally published in 1966).

It can be operated over long distances with minimal signal loss and a varying load impedance or supply voltage has no significant effect on the signal as long as the recommended component limits are not exceeded.

At the same time, the fact that the offset zero point verifies the electrical function of the sensor is a welcome form of simple remote diagnosis. Above all, however, 4-20 mA offered considerable advantages in handling compared to the pneumatic 3-15 psi control signals used until then. In short, the concept is simple, reliable and cost-effective.

However, 4-20 mA systems have disadvantages of their own. During normal operation, no data other than the pure measured values can be transmitted. NAMUR NE 043 („Standardization of the signal level for the error information of digital transmitters") gives at least a recommendation for standardized error information (E) in addition to the measurement information.

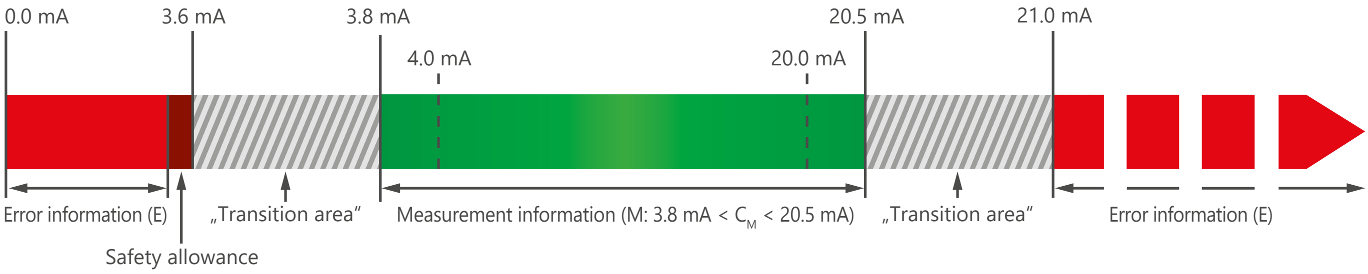


Image: Illustration of the limit ranges according to NAMUR recommendation NE 043, version 03.02.2003

The most important reasons still to use 4-20 mA systems:

- **About 90 to 95 percent of the existing information infrastructure consists of 4-20 mA systems**
  But it must be made fit for advanced requirements.

- **The cables are already where they are needed**
  After the commissioning of an industrial plant, the measuring points to be monitored hardly change. It may be necessary to add some measurement points due to new safety regulations, but the existing ones will not disappear or be placed in completely different locations.

- **The costs for a complete new installation of cables can easily exceed the acquisition costs of the gas detection system**
  It must therefore be considered whether the benefits of additional information would justify these costs.

- **Sometimes it is the only way to supply sensors with sufficient power even over long distances**
  Laying separate power supplies for energy-hungry sensors would only make such a gas detection system more expensive and unnecessarily susceptible to faults.

Today's 4-20 mA transmitters are no longer purely analog devices. They are powerful solutions equipped with electronics that use the signal ranges below 4 mA and above 20 mA to transmit additional information, such as error messages, but they are far from providing what one would expect from a smart solution in the age of the Industrial Internet of Things (IIoT).

Why not use HART in modern gas detectors?

Over the past decades, many clever minds have invested a great deal of time and effort in the development of the HART protocol and the corresponding devices. It is the perfect solution for many applications, but it was never intended to simply transfer additional data at low cost and high speed.

In many cases, the only reason for implementing HART is the fact that there is simply no alternative if you needed a digital communication protocol to send and receive information between the terminal devices and the control unit of a 4-20 mA interface. It's a bit like cutting a steak with a Swiss army knife: possible, but definitely not a stylish solution.

The most important reasons not to use HART:

- **The Bell 202 standard is no longer state of the art**
  It still works, but it was neither designed for today's computing power nor today's transmission capabilities. Your IIoT infrastructure requires and deserves more than just the transmission of a "Caller ID". The HART protocol is intended for process automation, and many of the performance and cost issues associated with it are due to the necessary (backward) compatibility requirements. What if you could use the digital protocol you' re using anyway?

- **It does not offer the option of integrating information from portable gas detectors into your safety system in the future**
  In order for transmitters to function as "radio hotspots" for portable gas detection devices, an excess of bandwidth is required on the 4-20 mA line. The next big thing in gas detection technology is to obtain a holistic view of all sensor readings, whether from stationary devices or mobile solutions.

- **It's not exactly cheap!**
  Interoperability has its price: Devices have to be tested and registered, the infrastructure beyond the existing cables is complex and sometimes costly, and it costs time and money to be a member of the FieldComm Group so that the protocol can be developed further.

The undisputed advantage:

What speaks in favor of HART is the wide choice of manufacturers and products, the interoperability and the fact that the systems have proven themselves in practice for many years are among the great strengths of the protocol.

ACDC is therefore not intended to compete with HART, but to complement it. It can easily exist in parallel with HART installations. Whenever the focus is less on process automation and more on fast and cost-effective transmission of safety and/or cost-relevant information, it covers a longstanding industry requirement.

Simplicity as a design principle

To make it for our customers and implementation partners as easy as possible, we have decided to stick with the digital protocol that we already use for our digital transmitters: Modbus/RTU. It is widespread and established.

All that remained was the challenge of superimposing the Modbus protocol on the transmitter's analog 4-20 mA signal. For its purposes, the HART protocol uses Frequency Shift Keying (FSK).

The analog current signal is modulated with a sinusoidal signal whose frequency changes from 1.2 kHz to 2.2 kHz - depending on whether a logical "1" or "0" is transmitted. It's a complex and therefore costly procedure. It would be much easier if no signal transformation was required.

ACDC achieves this by superimposing an amplitude modulation on the 4-20 mA current signal to generate a digital data stream. All that is needed are a few discrete components and a serial interface available in almost all microcontrollers. This allows for transmission rates of up to 38,400 bit/s.

The advantages of ACDC

The great advantages of ACDC are hardly visible at first sight. You might think that not much has changed. But it is somehow comparable to a Porsche engine put into a beetle chassis.

As long as the transmitters are not digitally addressed, they behave like normal devices on a 4-20 mA interface. Although you will need to replace the old transmitters with ACDC-enabled ones, the system at first looks the same as before. Retrofitting and migration are thus possible without any problems within the scope of normal maintenance cycles.

It all changes the moment you switch to digital communication and the full bandwidth of ACDC becomes available. All communication via ACDC is digital, including the transmission of measured values, but the analog current signal used as a carrier is still fully functional and serves as a backup and failover in case of an error in digital transmission.

Advantages:

- No need to lay new cables
- A step by step exchange of transmitters is possible
- Transfer rates of up to 38,400 Bit/s (HART 1,200 Bit/s)
- Suitable for Ex zones
- Range >1.200 meters
- Using the same protocol as transmitters that communicate via digital bus
- Cost effective solution

However, with ACDC we are only at the beginning of the development. We are working hard to integrate ACDC into our equipment series and to develop new service, maintenance and compliance processes as well as enhanced security concepts in cooperation with interested manufacturers and customers from various industries.

A glimpse into future

Even when transmitting all the additional information available from smart sensors and ACDC-enabled transmitters, the available bandwidth will rarely be fully used. This allows for a solution in which alarms and even readings from portable gas detectors are fed wirelessly into the stationary gas detection system and thus become part of the alarm system.

Portable gas detection devices from GfG come with an optional radio module. With the portable TeamLink it is already possible to monitor teams of up to 10 people. However, with regard to the safety of lone workers and small work forces, it would be desirable to integrate all portable devices into the stationary safety infrastructure. This would significantly improve security in the workplace.

To achieve this, transmission by radio signal offers considerable advantages over solutions based on WLAN, mobile or satellite telephony. And ACDC will provide the backbone to do so wherever you only have 4-20 mA interfaces on site.

ACDC is not specifically aimed at gas detection.

The possibilities of ACDC are not limited to the field of gas detection. It is only the area we at GfG are familiar with and with which we started, as we needed such a solution ourselves. But which protocol is transmitted by ACDC does not really matter. Therefore, we are currently working on converters for other protocols to make cross-system communication as easy as possible.

If you have a problem to solve and think that the ACDC could be the answer, let us work together on it.

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