Analogue signal conditioning questionary

Where…are analogue conditioners used?

In all types of electronic industrial and marine measurement and control systems – for example in processes such as power plants, steelworks, water and waste plant, oil and gas production and chemical processing. In fact, wherever temperature, pressure, level, flow, weight, speed etc is measured and controlled as part of a continuous or batch production process. Such measurement parameters – after being accurately produced – must not be degraded on their way from the field to the control room, despite external influences from the atmosphere and installation. Conversion or changes to these signals requires electronics of the highest quality, which can also withstand wide ambient temperature changes, electro-magnet interference, a vibrating environment, corrosive or hazardous atmospheres.

What…functions do analogue conditioners provide?

One or more of the following:

1) Isolation of high level DC measurement and control signals. (Why do we need isolation? – see the notes that follow later in this brochure.)

2) Conversion of high level signals, such as 0...5 V input to 4…20 mA output

3) Amplify, linearise and transmit low level sensor inputs, such as millivolts from thermocouples, into high level DC outputs to enable transmission over distances 100 m or more.

4) Initiate status indications and alarms by creating relay contact closure outputs from analogue inputs.

Why…do we need separate analogue module nowadays? Surely the control system (PLC or DCS) can perform the same functions?

1) Sometimes this is true, but look at where the cabling from the field devices (transmitters, sensors, valves and actuators) needs to go. It will usually go not just straight to the control system. Many signals are also passed to local indicators and alarms, and each will need isolating from the others.

2) Often sensors - like thermocouples for temperature – need isolating, converting and linearising locally to a standardized high level signal (e.g. 4…20 mA) for long distance transmission – instead of running expensive compensation cable to the control system.

3) Where the control system has no isolated analogue inputs, a separate isolator will often be needed.

4) Where the control system cannot provide power for the senor / transmitter and it is convenient to do this from an isolating module.

5) Where a high integrity, dedicated display is required, separate from the control system display, and the input needs splitting.

6) Where local linearization is needed for a plant operator – for example where a liquid volume indicator is needed for filling a bulk storage tank, but the measurement is level (level to volume conversion depends on the shape of the tank).

7) Where the control system only takes 4…20 mA analogue inputs and the sensors provide other less common ranges, such as 0…20 mV, 2…10 V, 0…10 kΩ, 0…1mA, 4…12 kHz, 0…5 A AC etc

8) Where the control system needs to be protected from electrical noise pulses on it's analogue inputs

9) Where expansion of the analogue inputs would mean an expensive new I/O board for the control system

How…can I select the right product for my application?

1) Weidmüller has a formidable range of analogue conditioners, covering most application requirements, and our range is expanding. We also have some useful tools for selection and configuration.

2) If you cannot find a suitable product for your application, it doesn't mean we don't have one! Tell us your requirement, and if we can't provide a solution from our current range of products, there may be a customized version that we could create for you.

Different types of analogue signaling

The working environment can be measured in many different forms, e.g. in terms of temperature, humidity or air pressure. The values of these physical variables change constantly. Elements that monitor the statuses and status changes of a given environment and supply an indication of this changing environment must be able to portray the continuous change.

In industrial monitoring tasks, sensors are responsible for registering ambient statuses. Sensors provide signals which allow detailed conclusions for downstream evaluation and monitoring systems with detailed conclusions about the statuses or status changes, e.g. in a production process. Sensor signals monitor continuous changes in the field. They occur in digital and analogue form. As a rule, they supply an electrical voltage or current value which corresponds proportionally to the physical variables being monitored.

If automation processes are expected to reach certain statuses or keep them constant, then analogue signal conditioning is required. It is also important in areas where this has already been part of long established practice, e.g. in process engineering or the chemicals industry.

In process engineering, standardised electrical signals are normally used. Currents of 0 … 20 mA, 4 … 20 mA or voltages of 0 ... 10 V have become established as the output variables for sensors recording various different physical parameters.

Weidmüller takes account of the growing preference for automation – including and in particular with analogue signal conditioning – and offers a wide range of products tailor-made to the requirements involved in handling sensor signals. Units for the common signals (0 ... 20 mA, 4 ... 20 mA, 0 ... 10 V) generate an output signal as a proportional value of the variable input signal. “Protective separation”, e.g. of the sensor circuit from the evaluation circuit, is also taken into account. “Protective separation” prevents mutual interference among several sensor circuits, e.g. as in the case of earth loops in interlinked measuring circuits.

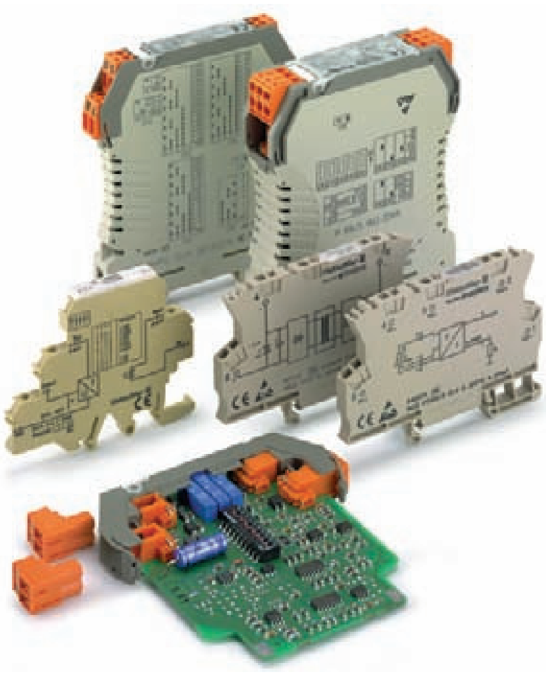
The wide range of Weidmüller products completely covers the functions involved in signal conversion, signal separation and signal monitoring. The products can thus handle nearly all applications in industrial measuring technology, and safeguard elementary functions between field signals and further processing systems. The mechanical properties of the products are built up around a consistent concept.

Signal converters can be used with other Weidmüller products and combined with each other. They are designed to entail a minimum wiring workload and maintenance in both electrical and mechanical terms.

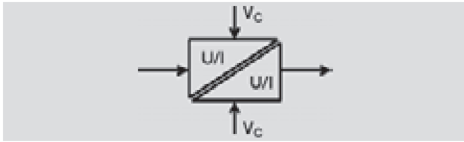
The product range contains the following functions:

- DC/DC converters
- Current converters
- Voltage converters
- Temperature transformers for resistance thermometers and thermoelements
- Frequency converters
- Potentiometer transducers
- AC transducers
- Bridge transducers (strain gauges)
- Threshold monitoring modules
- AD/DA converters

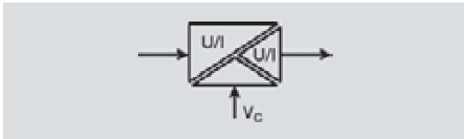
The products are available as pure signal conversion, 2-way isolation, 3-way isolation and passive disconnectors – depending on the production functions in each case.



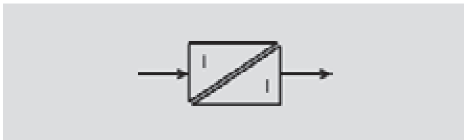
2-way isolation separates the signals from each other electrically and decouples the measuring circuits. Potential differences – caused by long line lengths and common reference points – are eliminated. Furthermore, the electrical separation protects against irreparable damage caused by overvoltages as well as inductive and capacitive interference.



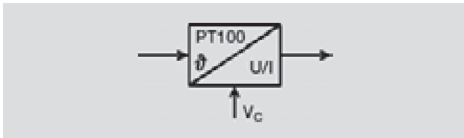
3-way isolation decouples the supply voltage from the input and output circuits as well and enables the function to operate with just one operating voltage.



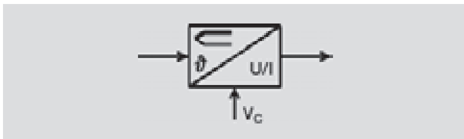
The **passive separator** offers an extra, decisive advantage – it requires no additional voltage supply. The power supply to the module is achieved via the input or output circuit and is transmitted to the input/output. This current loop feed is characterised by a very low consumption.



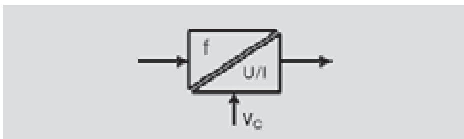
A number of products are available for temperature measurements. For example, **PT100** signals in 2-, 3- and 4-wire systems are converted into standard 0…20 mA, 4…20 mA and 0…10 V signals.



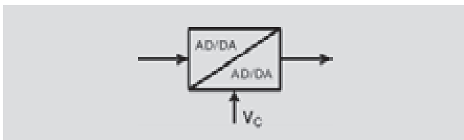
The modules for connecting conventional **thermoelements** are fitted with cold trap compensation as standard. Furthermore, they amplify and linearise the voltage signal provided by the thermocouple. This guarantees accurate analogue signal conditioning while eliminating sources of interference or error.



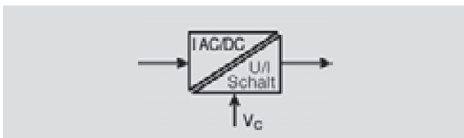
Frequency converters convert frequencies into standard analogue signals. Downstream controls can therefore directly process pulse strings for measuring rpm or speed.



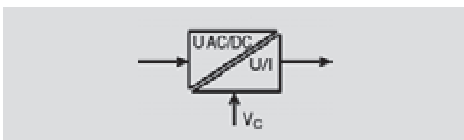
AD or DA converters are required for bringing together the analogue signal forms mapping the local conditions and the digital processing in the process monitoring system. Weidmüller can supply such components for the customary 0…20 mA, 4…20 mA and 0…10 V input and output signals. 8-bit processors are available on the digital side.



Current monitoring modules make it possible to control limiting currents and AC currents up to 60 A. A switching operation is triggered when the set current values are not met or exceeded. Components with analogue outputs monitor the current load continuously via downstream controls.



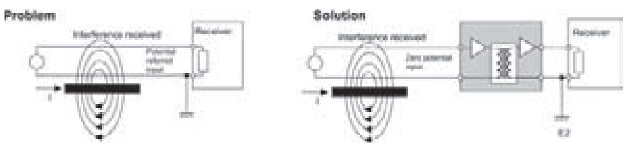
Voltage monitoring modules can be used to monitor AC and DC voltages. Adjustable switching thresholds can be used to reliably detect and notify in the event of fluctuations caused by switching operations or mains overloads.



Technical data

Common Mode Noise Elimination

- Generally, signals emitted by sensors have low levels and are thus susceptible to capacitive and inductive interference, such as those generated by motors, frequency changers and other change processes.
  This noise contents the measuring value and frequently destroy expensive analog I/O cards in the control electronics. Through the utilisation of analog signal isolators this interferace, which usually action both signal lines in common mode (push push), is effectively eliminated through the zero potential input.

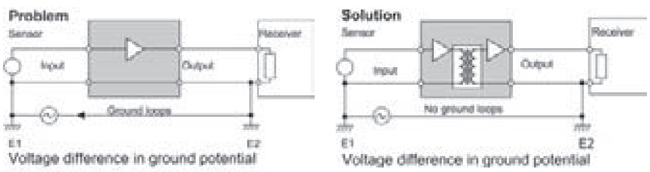


Active Isolator / Passive Isolator

- Active isolators draw their power supply from a separate supply terminal to ensure that they can operate perfectly. Depending upon the applications the input, output and additionally the power supply are isolated from each other. Only one supply is required for 3-port isolation. However, it is isolated from the input and output circuits. Thus even in the event of a short circuit, surge voltage or reverse polarity, the downstream control electronics cannot be damaged. Isolating the signals between the input and output can be conducted either optically or by transformer barrier depending upon the transfer rate. Active isolators are non interacting, i.e. a change in the load does not exert any influence on an input circuit.
- Passive isolators generate the current required for the supply from the measuring signal. The current required internally is so small that transfer problems do not occur here.
- The feed can be effected from either the input or the output side. Isolation is by transformer barrier. The advantages are: cessation of network influences, outstanding accuracy, low signal delay and low potential requirement. Passive isolators are not non interacting; a change in load in the output circuit will influence the input circuit.

Ground Loops

- The voltage supply's secondary side is earthed for the purpose of setting up fast and secure ground loop monitoring. If an analog signal is fed in from a separate voltage supply or if the sensing device itself is earthed, then transient currents will flow between the ground potentials across the interconnected ground connectors, which in turn corrupts the measuring signal.
  Analog signal isolating amplifiers prevent this form of measuring signal corruption and influence.



2-port Isolation

- The simplest form of analog signal isolator is that of 2-port isolation. It serves to isolate the input circuit from the output circuit as well as the two auxiliary voltages from each other. Depending upon the isolator design and the observed isolation data one refers here to base isolation (galvanic isolation) or safe separation. ①
  For current signals, 4...20 mA input current loop fed modules are available. An additional auxiliary voltage for the input circuit is not requin with here. ②
  By connecting the input and output side voltage supplies, the 2-port isolation can be converted to operate as a simple signal converter. This is of particular interest where isolation is not required for an application, but a signal conversion has to be performed.

①

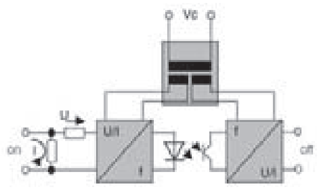
②

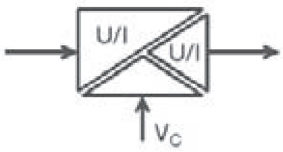
3-port Isolation

- 3-port isolation is the most universal form of signal isolator
- An optical coupler or transformer isolates the input from the output circuit. Together with the clearance and creepage distances it serves to define the isolation level. For example, the input signal is converted by means of pulse-width modulation into a frequency signal and demodulated again on the output side to form an analog value. An amplifier then generates a standardised analog signal. A galvanic isolated DC/DC converter feeds the input and output circuit with a potential free supply voltage. It too determines the isolation level through its data, air and creepage distances.
  In the case of these three isolation paths (input/output, input/auxiliary voltage, output/auxiliary voltage) one refers to 3-port isolation.

Temperature Signal Measuring Method

- Measurement using resistors (RTD)
  When measuring with temperature-dependent resistors a current of approx. 1.5mA is passed through the resistor from a constant current source in the signal converter.



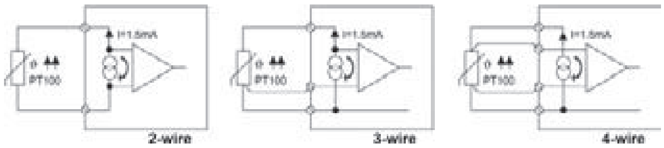


An operational amplifier is used to measure the potential drop at the resistor (2-wire circuit).
In order to take account of lead length, the voltage drop is measured at the return conductor and calculated with double the value (3-wire circuit). This thus simulates the wire resistances from the feed and return lines.
Accurate measurements are achieved by separately measuring the voltage drop at the feed and return lines (4-wire circuit). The values for the supply lines are calculated against the measured value.

Temperature Signal Measuring Method

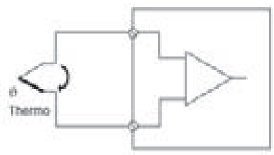
- Measurements using thermocouples
  When conducting measurements using thermocouples the voltage that is generated when two differently alloyed metals come into contact with each other is measured.

A differential amplifier is then used to recondition the signal. The easiest (and thus the most cost effective) method of sub sequent processing is conducted by means of an amplifier circuit, which converts these signals into standard signals. High-end components process the measuring signal using a microprocessor, which simultaneously reconditions the signal (filtering, linearisation)



Cold Junction Compensation For Thermocouples

- Recording temperatures by using thermocouples encounters the problem of a thermal voltage forming at the clamping terminals on the signal converter on account of the different materials in the conductors and bus bar. This voltage then counteracts the thermal element's voltage.



In order to compensate for the error to the measured value which arises here, the temperature is measured at the clamping terminal. The microprocessor in the signal converter reads the value measured there and calculates it against the measured value. This procedure is known as cold junction compensation.

Voltage at the measuring point (V_{meas})
+ Voltage at the terminal ($V_{terminal}$)

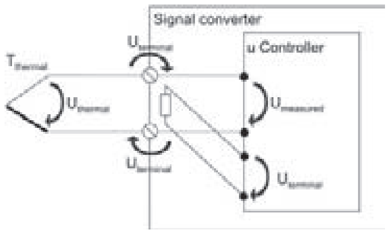
= Voltage at the thermocouple (V_{thermo})

=> Temperature at the thermocouple (T_{thermo})

Linearisation

- Temperature-dependent components do not normally have linear characteristic curves. To ensure that further processing can take place with the necessary accuracy, these characteristic curves have to be linearised to some extent.
  The graph showing measurements of thermocouples, in particular, reveals significant deviations at some points from the "ideal graph". As a consequence, the signal which has been measured is worked up by a microprocessor.

Introduction

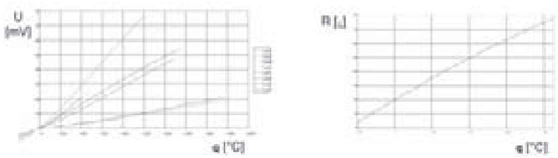


The microprocessor compares the value measured with the characteristic curve for the thermocouple in its memory and calculates the corresponding value on the “ideal characteristic curve”. At the output, it supplies the latter to an amplifier, which produces the analogue value in linear form. The output stage converts this into a standardised value or into a switching output with a switching threshold.

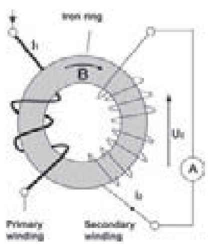
The linearisation of PT100-elements can be undertaken via simple amplifier stages. The first stage corrects the peak val ue of the graph of the measurements. The deviation at the end of the graph resulting from this is corrected by a second stage. The under- and over-shooting generated in this way is very slight and is covered by the tolerance for the module.

Current Measurement Using A Measuring Transformer

- Transformer principle Each conductor through which current flows is surrounded by a magnetic field H, the intensity of which is proportional to the current. The field, which is bundled in a magnetic core, generates a magnetic flux B, through which suitable sensors are used to measure current.



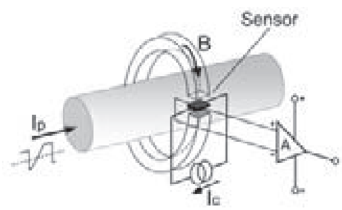
Converters with transformer-type couplings are used to establish the most cost effective measurement method for simple sinusoidal currents. The current to be measured flows directly through the measuring transformer‘s primary winding.



The secondary winding supplies the measuring electronics with a proportional current signal. Because of power loss this method of measuring current is limited to smaller currents up to 5 A. These converters react sensitively to peak loads and therefore have to be fused on the primary winding side.

Measuring Current Using A Hall-type Sensor

- Hall-type sensor principle
  Hall-type sensors also measure the magnetic flux B and supply a proportional voltage at the measured output, which is then reconditioned to form a standard signal by an amplifier circuit.
- Components with Hall-type sensors are ideally suited to measuring higher currents, as any possible high residual currents from motors or peak loads cannot damage the component. Additionally, they are also ideal for measuring direct and alternating currents of various curve shapes.

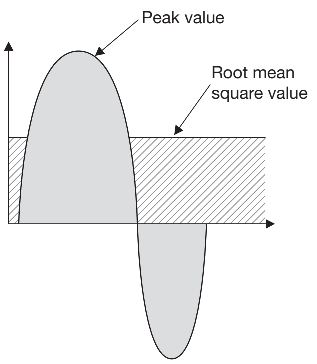


Root Mean Square Measurement / Crest Factor

- The root mean square value (r.m.s) of a sinusoidal shaped alternating current is the value, which in an ohmic resistor converts the same (effective) output as that of an equal sized direct current.
- Non sinusoidal shaped signals can only be measured with “True RMS” capable devices and/or further processed.
- True RMS = True root mean square
- Root mean square measurement is required where the (effective) output content of alternating voltages or currents are to be measured or evaluated.
- The crest factor indicates the ratio of the crest factor to the root mean square value.

Load / Load Resistor

- The load is a load resistor on the output side of a measuring transducer or isolating amplifier.
  For current outputs the load is generally 500 Ω.
  Voltage outputs usually have a 10 KΩ load.



Galvanic Isolation / Safe Separation

- Galvanic isolation is understood to mean an electrical isolation between the input and output circuit and the circuit‘s supply voltage. It can be set up either optically using an opto coupler or with a transformer. The isolation serves to safeguard the measuring circuit against damage and to eliminate ground loops, which could cause the measured signal to be corrupted.
- Safe separation is specified under the German DIN VDE 0106 Section 101 standard. This fundamental safety standard is intended to safeguard persons against hazardous body currents and describes the basic requirements for safe separation in electrical operating equipment. Thus, for instance, the voltage supply of 50 V AC/ 120 V DC as under 50178 may not be exceeded. If this voltage is exceeded a reinforced or double insulated and thus an increase in the clearance and creepage distances is stipulated.

Cut-off Frequency

- Cut-off frequencies indicate the dynamic transfer characteristic of an isolation amplifier.
- The given frequency is the (-3dB-) limit, at which a distinct change occurs to the signal.
- An increased cut-off frequency leads to a transmission of higher-frequency alternating components, which corrupts the required signal.

Hysteresis

- Hysteresis indicates the percentage difference between the input and output points of a switching contact. It should not be lower than a given minimum value, as otherwise a specified chase can no longer be implemented.

Broken-wire Detection

- When measuring transformers with
  broken wire detection the input signal is monitored permanently. In the event of a fault (broken wire) the output signal exceeds its rated range. The downstream control circuit can then analyse the fault case.

Response Time

- Response time refers to the change in output signal for an input signal jump (10...90 %). It is directly related to the cut-off frequency (inversely proportional).

Accuracy / Temperature Coefficient

- Accuracy describes the capability of a measuring device to deliver a measured value as accurately as possible. It relates to the end value and is given for ambient temperature (23°C).
  Example:
  An RTD is given with an accuracy of 1 %. The measuring range is set to 0-200 °C. The expected effective error of:
  200*1 % = +/– 2K applies across the entire measurement range.
- Temperature coefficiency describes the deviations in accuracy of the measuring devices dependent on the ambient temperature. It is given as a % or in parts per million / Kelvin (ppm /K).
  Example:
  An RTD with an accuracy of 1 % and a measuring range of 0-200 °C has a temperature coefficiency of 250 ppm / K. If the device is operated at +40 °C, it will then contribute the following to an expected absolute error:
  (([40°C-23°C] *250ppm/K) +1%) *200K) = +/- 2,85K
  across the entire measurement range.