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Data_Link 2000

APPLICATION NOTE AN007

Analogue Accuracy

Summary

In some applications analogue accuracy is critical to the system operation. Many users are confused by terms such as resolution, temperature coefficient, linearity, FSD accuracy and absolute accuracy. Some manufacturers oversell their products by quoting accuracy in favourable terms that do not relate to actual performance. This application note attempts to explain the terminology.

Outline

Any system that processes analogue signals is prone to introduce errors. For example, simply amplifying a signal can introduce offset errors, gain errors, linearity errors and noise. Furthermore all of these may be influenced by environmental conditions such as temperature and supply voltage.

If the signal is processed digitally another source of error is quantising distortion. If an 8-bit analogue-to-digital converter (ADC) is used, it can only convert the analogue value to one of 255 discrete steps. This results in an inherent worst case error of ±0.2%. This can be reduced to ±0.012% by using 12-bit conversion. However, in any system other sources of error are likely to be significantly greater than the quantising error.

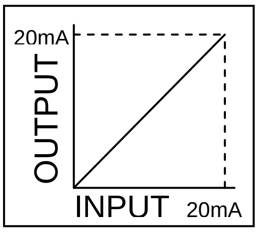
Even a badly designed system is likely to be perfectly accurate for a particular signal level, at a particular temperature. However, the user’s interest is in the overall worst-case accuracy over the full range of signal level and temperature. **Accuracy is not dictated simply by the resolution of the ADC!**

Data_Link 2000 uses 12-bit conversion on all analogue inputs and analogue outputs, except the outputs on the ***Nano_Link*** and ***Micro_Link*** modules, which are 8-bit. It also incorporates various steps to improve accuracy (including digital calibration techniques) to cancel out most sources of error, resulting in an overall accuracy of ±0.2% (±0.5% when using outputs on the ***Nano_Link*** or ***Micro_Link*** outputs).

Note that it is our policy to quote overall worst-case accuracy, including errors introduced at the input and the output, over the full operating temperature range.

Ideal Characteristics

If a graph is drawn of output vs input, the ideal characteristics would be a straight line at an angle of 45^o, passing through the origin:



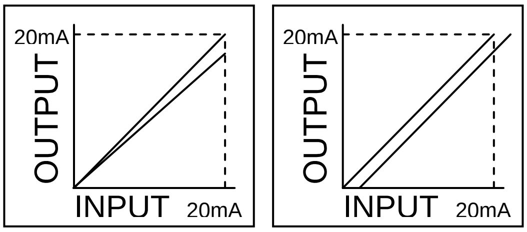
Any deviation from this ideal represents a potential source of errors.

Since signals are usually in the range 4…20mA, some systems inject a 4mA offset at the input, then process the signal in the range 0…16mA, with the intention of increasing accuracy. However, the potential errors introduced by the offset usually exceed the 25% improvement in resolution.

The ***Data_Link 2000*** system therefore processes signals in the range 0…20mA. This has the obvious benefit of identifying faulty transducers that may be giving an output of less than 4mA.

Gain and offset errors

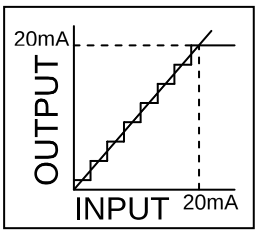
Any analogue amplifier will exhibit a tolerance on its gain, and will introduce a zero offset. These may be depicted as follows:



These cannot be eliminated, but they can be minimised by using high-quality components.

Quantising errors

When an analogue signal is converted to a digital representation there is invariably a potential quantising error introduced, which can be depicted as follows:



The worst case quantising error is half the resolution, or ±0.2% of FSD for an 8-bit ADC, and ±0.012% of FSD for a 12-bit ADC.

Note that ADC's saturate at a defined level. In the case illustrated a faulty transducer which may give an signal of greater than 20mA cannot be detected. ***Data_Link 2000*** products are calibrated for a range 0…20.48mA to overcome this.

Noise

The input signal will inevitably include 50Hz pick-up from mains power as well as inherent electronic noise.

Another significant source of noise in radio telemetry systems is RF interference from the transmitter affecting the signal source. This is eliminated in ***Nano_Link*** by ensuring that the radio transmitter is off when the analogues are read.

Data_Link 2000 minimises the effect of noise by preceding the ADC with a low-pass filter, then taking 255 readings and averaging them.

Other sources of error

The above discussions assume all components are linear. Non-linearity will result in deviations from a straight line. All sources of error will also be influenced to some extent by temperature, but this can be minimised by careful selection of components.

All the above discussion relate to the input ADC process, but identical considerations apply to the digital-to-analogue process used at the output.

Overall Accuracy

When quoting overall accuracy, all the sources of error described must be considered, and worst-case conditions should be quoted.

A common misconception is that a system with a quoted accuracy of ±0.1% will be accurate to ±0.004mA for a signal of 4mA. Since most sources of error are independent of the signal level, accuracy is usually related to the full-scale range, so 0.1% accuracy means ±0.02mA.

Digital Calibration

Micro_Link and ***Nano_Link*** employ software calibration to cancel gain and offset errors. The digital representation of 2mA and 20mA signals is recorded and stored in memory during production testing. All subsequent reading are then processed to cancel the known errors.

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