MULTI-CHANNEL ADC BRINGS FLEXIBILITY TO SENSOR CONNECTIONS

by Maxim Integrated

Today's industrial processes often require continuous monitoring of temperature and pressure signals from connected sensors. The signals from these sensors are typically voltages (in the range of ±20V), currents (in the range of 4-20mA), thermocouple (TC) signals or the output from two-, three- or four-wire resistance temperature detectors (RTD). The signals from these sensors are transmitted—often in harsh and noisy environments—to the analogue I/O module of a programmable logic controller (PLC) (Figure 1) or a data recorder. Designers of such equipment face a challenge in ensuring that they can provide sufficient numbers of input channels for each signal type, maintaining signal integrity without significantly increasing their equipment size and cost.

Figure 1. *Programmable logic controller*

This design solution looks at common approaches for simultaneously monitoring different types of industrial analogue input signals and presents an innovative alternative which offers a new degree of design flexibility.

MULTIPLEXING THE INPUTS

High-end, high-reliability sensor monitoring systems initially used a separate ADC for each input channel. However, this approach increased the design complexity (and ultimately the cost) of any system. To avoid the need for a single ADC per input channel, a common solution has been to insert an integrated multiplexer at the input to the ADC (Figure 2) to simultaneously monitor several different channels (when sequenced at the required sampling rates). These multiplexers often have between six and twelve input channels. However, due to the variety in the type (current/voltage/RTD/TC) and nature (single-ended/differential) of these signals, it has been a common approach to allocate signals of the same type and/or nature to dedicated groups of multiplexer inputs.

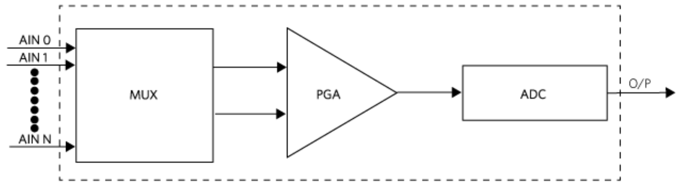

Figure 2. *Multiplexing sensor inputs to an ADC within an IC*

The most common approach has been to assign a pair of multiplexer inputs to each sensor. This allows the ADC to measure signals which are either single-ended or differential in nature, but has the negative effect of reducing the total number of sensor inputs, which can be monitored. For example, a six-input multiplexer can only receive signals from three sensors regardless of whether the sensor output is differential or single-ended.

SOURCING CURRENT

An added degree of complexity in such a system design is that excitation current sources are required by some sensors, specifically RTDs. External circuitry has traditionally been used to provide this current. Alternatively, the excitation current may be sourced from one of the multiplexer inputs of the ADC, if such functionality is provided for in the IC. In this scenario, however, the functionality is typically only available on some of the input channels. This places a further restriction on the type of sensor inputs that can be connected to certain channels of the multiplexer. Furthermore, it is imperative that the current source has the required degree of granularity to ensure that the sensor input is within the dynamic range of the ADC. To accommodate the variety and nature of input signals, the only option for the designer has been to use ADCs with additional multiplexer channels or to use more than one ADC. Obviously, this has the effect of adding to the complexity (and ultimately the cost and size) of the design.

FLEXIBLE ALTERNATIVE

The ideal scenario for the system designer would be an integrated multiplexer and ADC which places no restriction on the type and nature of the signal connected to any input channel. The MAX11410 multichannel 24-bit ADC is one such device. It features a ten-channel input multiplexer with the added advantage that any of the inputs can be used either in single-ended mode or in conjunction with any other channel in differential mode. Furthermore, any of the inputs can be used as a current source to an external sensor. The MAX11410 can accommodate up to ten single-ended input channels or five differential inputs or combinations of single-ended or differential channels, as required. The MAX11410 also provides for a choice of three reference inputs. Figure 3 illustrates an application of the MAX11410 measuring temperature with two 4-wire RTD inputs.

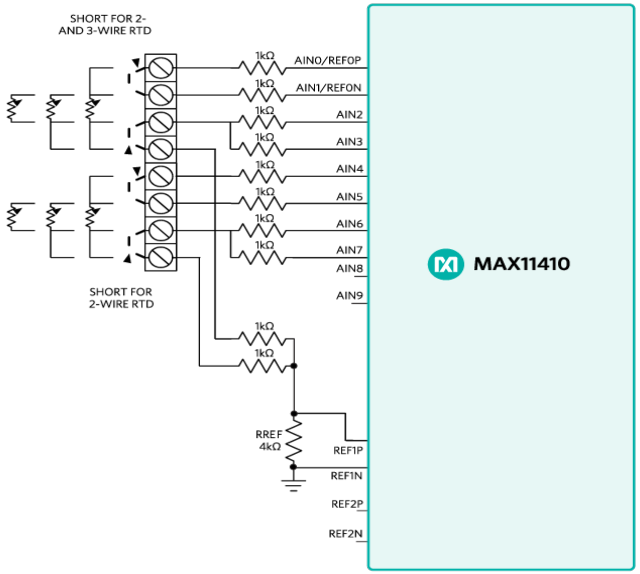

Figure 3. *Two-RTD temperature measurement circuit*

In addition to the degree of flexibility offered in the choice of sensor inputs, the MAX11410 offers features which simplify design of precision sensor applications. The current sourced from the input channels ranges from 10 µA to 1.6 mA in sixteen programmable steps. Furthermore, a programmable gain amplifier (PGA) with gain settings between 1x and 128x ensures that even sensors with very low output levels can be amplified to fall within the dynamic range of the ADC. An extremely important requirement for devices operating in noisy industrial environments is the ability to reject mains frequency (50/60 Hz) interference, for which the ADC offers 90 dB of multi-harmonic rejection, ensuring excellent signal integrity. A broken wire/burnout detect function helps find sensors that need to be replaced. This functionality is housed in a TQFN package with a small footprint (4 x 4mm), which consumes only 400 µA of current in typical use.

In this design solution, we have reviewed the options available to the system designer for monitoring signals from multiple sensors in an industrial environment. Having considered the limitations of previously available solutions, we can conclude that to monitor multiple sensor inputs simultaneously, a better option is to use an integrated device. This provides the highest degree of flexibility for accommodating the differing types and nature of signals being received. In this regard, the MAX11410 offers the system designer the opportunity to achieve a greater level of efficiency in their designs, since every input channel can handle all signal types, reducing the requirement for extra external circuitry. In addition to use in industrial PLCs, the ADC is also suitable for portable instruments, industrial weigh scales and a variety of Internet-of-Things (IoT) applications.