High-accuracy sensor signal processing circuits

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Kouji Mochizuki

Many household appliances, industrial and process control systems and medical instrumentation have sensors. In such systems, sensor interface circuits improve their performance. In this study, interface circuits for high-accuracy sensors were developed.

For a resistance sensor, resistance-to-frequency converter was developed. The converter is based on the relaxation oscillator consisting of Wheatstone bridge followed by an integrator and a comparator. By incorporating the nonlinear and delay compensation scheme into the basic architecture, the resolution and the linearity higher than 5×10^{-4} and 2×10^{-5}, respectively, has been achieved.

For a differential capacitance transducer whose two capacitors C_1 and C_2 change complimentally with a measurand, four interface circuits were developed which perform the ratiometric operation $(C_1-C_2)/(C_1+C_2)$. The first is based on the capacitance-to-voltage (C/V) conversion. An A/D converter is used for the ratiometric operation. In this architecture, one C/V converter is commonly used to detect C_1 and C_1+C_2, to minimize the error due to the nonideal behaviour of the C/V converter. A prototype interface has detected the relative capacitance change as small as 3.4×10^{-5} with the accuracy higher than 10^{-3}. The second interface is also based on the C/V conversion, but the feedback technique is applied, instead of an A/D conversion, to perform the ratiometric operation. With this feedback architecture, the relative capacitance change as small as 6×10^{-5} can be detected.

The third interface is based on a relaxation oscillator consisting of an integrator and a comparator. The two transducer capacitors are alternately connected by diode switches to the integrator. This multiplexing converts the capacitance ratio into the duty ratio of the oscillator output. A prototype interface has achieved the relative accuracy as small as 2.6×10^{-5}. The fourth interface is synthesized by the state variable method, consisting of an integrator, a differentiator, and an inverting amplifier. The output of the inverting amplifier is fed back to the integrator, to form an relaxation oscillator. This architecture features a high-speed ratiometric operation and the detectable relative change is 10^{-3}.

Because of their high-accuracy signal processing, the circuits described in this thesis will find wide applicability in sensor interfaces.