Differential and Gauge Pressure Transmitters That Sophisticate Plant Monitoring and Control Systems

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ABSTRACT

Since its release in 1989, Fuji Electric's "FCX Series" of pressure transmitters have been used to monitor and control plants in various industries. The "FCX-A IV Series," the latest model developed to meet new needs, utilizes a capacitive pressure sensor to achieve high measurement accuracy and long-term stability, as well as fast response, high visibility, and better operability. Its unique structure allows this series to be used for hydrogen permeation resistance applications, and its use of optimal materials enables it to be utilized for corrosion resistance applications. Furthermore, the series uses piezo pressure sensors for applications that require ultra-high pressure resistance beyond the application range of capacitive pressure sensors.

1. Introduction

Since its release in 1989, Fuji Electric's "FCX Series" of pressure transmitters has been used to monitor and control plants in various industries, including chemicals, steel, waste treatment, oil and gas, while continuing to evolve in function and performance[1]. This paper describes the latest "FCX-A IV Series" of pressure transmitter models, which have been designed for greater reliability and ease of use to meet the new needs of customers.

2. Overview of the "FCX-AIV Series"

For the heart of the pressure detection unit, the FCX-A IV Series uses capacitive pressure sensors with an extensive track record, thereby achieving high measurement accuracy, while the optimized structure provides long term stability. In addition, the signal processing component has been enhanced to shorten the measurement cycle. A wealth of variations are available to support a wide range of applications. As an example, for fields requiring functional safety, the products have acquired Safety Integrity Level (SIL) 2 certification for the IEC 61508 international standard. In addition to a model with hydrogen permeation resistance, which is required for hydrogen production equipment, and a model with corrosion resistance that can be applied to various acid and alkali handling equipment, our lineup includes a model that can be used under high temperatures and high vacuum. Furthermore, we also offer a model with piezo pressure sensors in the detecting unit for applications that require ultra-high pressure resistance, such as offshore oil fields. Figure 1 shows the appearance of the FCX-A IV Series of differential and gauge pressure transmitters.

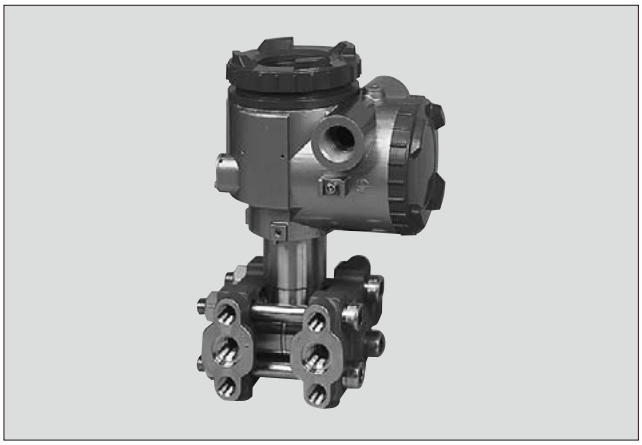

Fig.1 "FCX-A IV Series" of pressure transmitters

3. Features of the "FCX-A IV Series"

3.1 High accuracy and long-term stability

The capacitive pressure sensor used in the pressure detectig unit has higher sensitivity than other measuring systems, and it is made of a single-crystal silicon material, which has small hysteresis, resulting in excellent stability and reproducibility. In addition, the optimized structure has realized output with long-term stability. Furthermore, the advanced floating cell structure, in which the sensor floats in an incompressible fluid, protects the sensor from various harsh environments and excels in ensuring the stability of the sensor. With these features, the following performance characteristics have been achieved.

(a) High accuracy measurement: ±0.065% (standard)

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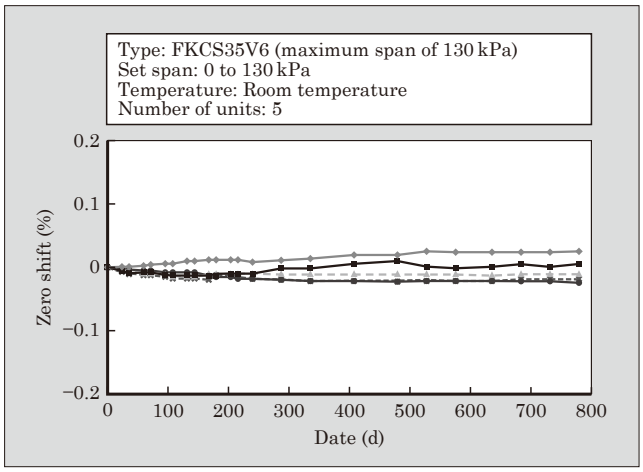

Fig.2 Zero shift data of the "FCX-A IV Series"

(b) Long-term stability: ±0.1%/5 years

Figure 2 shows the zero shift data of the FCX-A IV Series.

3.2 High-speed response

Distributed control systems (DCS), responsible for controlling plant operations, have become faster and more reliable as digital transformation (DX) has progressed, and accordingly, higher accuracy and higher speed are required also for field equipment such as transmitters. The performance of the FCX-A IV Series has been improved compared to the previous series due to the adoption of a high-speed CPU and the optimization of software processing, resulting in the highest level of responsiveness (update cycle of 40 ms, dead time of 60 ms) available in pressure transmitters. It is suitable for processes such as steam flow rate measurement for gas turbines that require high-speed response. Figure 3 shows the output response characteristics of the FCX-A IV Series.

3.3 Excellent visualization and usability

The equipped digital indicator shows digital measurements and units simultaneously, helping users gain an accurate understanding of the data. When an

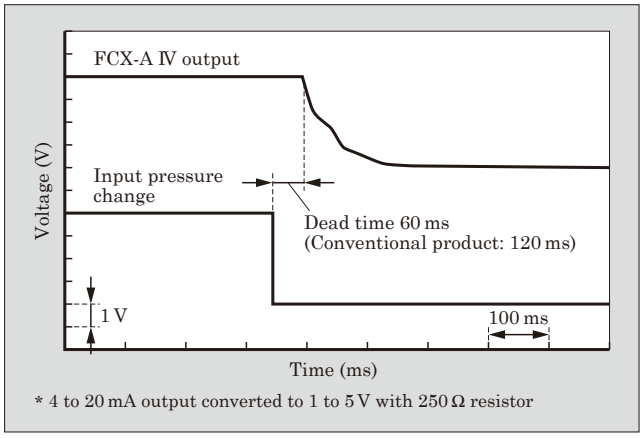

Fig.3 Output response characteristics of the "FCX-A IV Series"

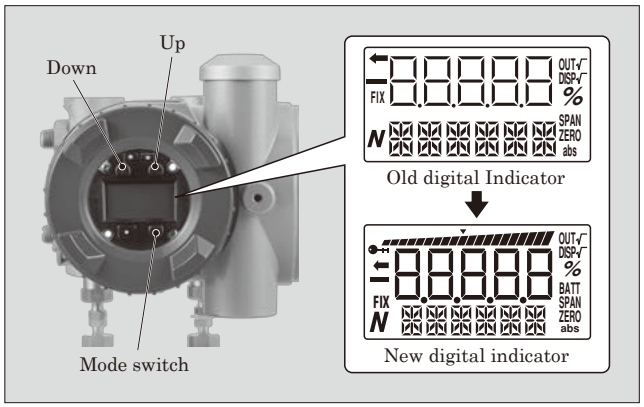

Fig.4 Appearance of the "FCX-A IV Series" digital indicator

abnormality occurs, an error code is also displayed, making it possible to quickly understand the situation and respond to the abnormality. The FCX-A IV Series also provides an additional bar graph display, allowing users to understand the situation intuitively. All parameters built into the digital indicator can be configured and adjusted without opening the indicator cover by using non-contact switches from the outside. Figure 4 shows the appearance of an FCX-A IV Series digital indicator.

3.4 Acquisition of SIL2 certification

This series is compliant with the IEC 61508 safety standard and has obtained SIL2 certification. It can be used in fields requiring functional safety. Further, implementing redundancy (combination) with two transmitters can achieve the level equivalent to SIL3 certification.

3.5 HART* communication support

The series is equipped with HART protocol output as standard and supports HART communication (the latest version, Revision 7), which can be easily coordinated across international worksites. Synchronization with a higher level controller enables engineering, monitoring, and equipment management for the HART system.

3.6 Responses to various applications

(a) Hydrogen permeation resistant applications

If a measured object contains hydrogen, a slight electromotive force is generated in the pressure-receiving diaphragm part of the transmitter, which is composed of dissimilar metals, and the hydrogen ions align there and permeate into the diaphragm. This is called the hydrogen permeation phenomenon, which will hinder accurate measurement. As a countermeasure, hydrogen permeation can be suppressed over long periods of time by applying gold plating to the seal diaphragm base material and

* HART is a trademark or registered trademark of FieldComm Group.

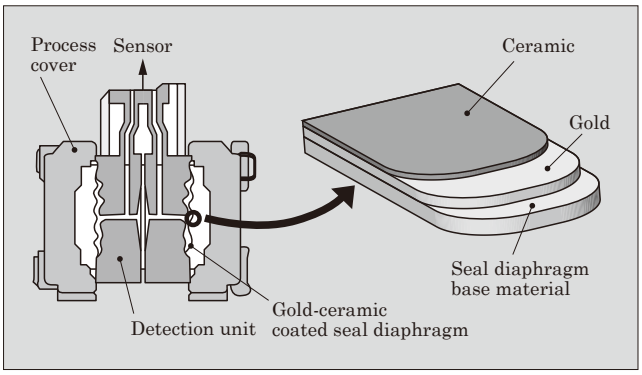

Fig.5 Structure of a gold-ceramic coated seal diaphragm

forming a gold-ceramic coating seal diaphragm with a ceramic film as an insulator. This structure is an original Fuji Electric technology that contributes to accurate hydrogen measurement at hydrogen purification plants and other facilities. Figure 5 shows the structure of a gold-ceramic coated seal diaphragm.

(b) Corrosion-resistant applications

In addition to hastelloy-C, monel, and tantalum, we offer titanium and zirconium as seal diaphragm materials. Selecting the optimal materials from a wide range of corrosion-resistant options can reduce the frequency of maintenance operations to deal with corrosion.

4. For Ultra-High Pressure Applications

4.1 Limitations of capacitance pressure sensors

In many offshore oil fields where pressure transmitters are used, the pressure is approximately 100 MPa. However, in recent years, as the depth of oil fields has increased, the pressure has exceeded 130 MPa in some fields. Under such ultra-high pressure, it becomes difficult to apply capasitive pressure sensors. The detected capacitance is determined by the electrode area, the distance between electrodes, and the permittivity of the sealed oil that fills the space between electrodes. However, the permittivity of the sealed oil changes according to the pressure, and the difference in the permittivity between the high pressure side and the low pressure side of the sensor increases in the high pressure range, resulting in errors. In addition, in the low pressure region, the capacitance is formed by a uniform gap formed by electrodes positioned opposite to each other in parallel, but in the high pressure region, the diaphragm becomes deformed, causing the gap to become uneven, which also results in errors. In addition, fluids measured in offshore oil fields, such as crude oil, groundwater and water vapor, contain hydrogen sulfide and salt, which are highly corrosive. For this reason, high corrosion resistance is essential for wetted parts such as seal diaphragms.

4.2 Ultra-high pressure capacity with piezo pressure sensors

We have developed a model that uses piezo pressure sensors for ultra-high pressure applications. Figure 6 shows the appearance of a pressure transmitter for ultra-high pressure applications.

The piezo pressure sensor detects the stress generated in the diaphragm by the pressure as a change in the piezo resistance value. The piezo pressure sensor is manufactured by forming a resistor and a wiring pattern on the surface of a silicon substrate, as well as a diaphragm on the back using dry etching, then using surface activated bonding to bond it together with a glass substrate before cutting them into the shape of a chip. As shown in Fig. 7, the structure of the chip is very simple. In addition, since substrates are bonded directly to each other at normal temperatures when using surface activated bonding, the high temperatures and high voltages applied in the commonly used anodic bonding technique are avoided, which means that deterioration of the substrates and residual stress do not occur. Compared to capasitive pressure sensors, there are fewer parts that deform and become error factors. For this reason, pressure can be detected

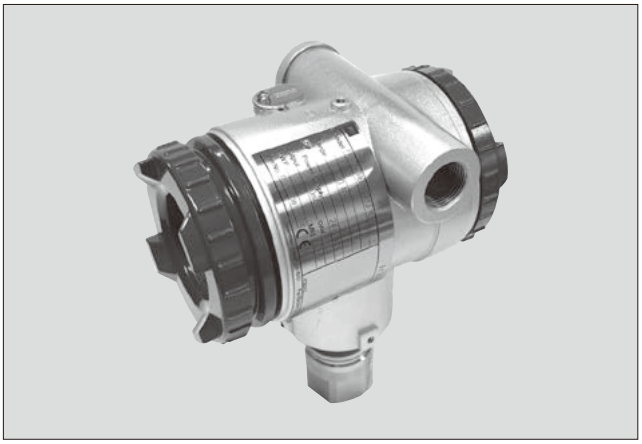

Fig.6 Pressure transmitter for ultra-high pressure applications (with a built-in piezo pressure sensor)

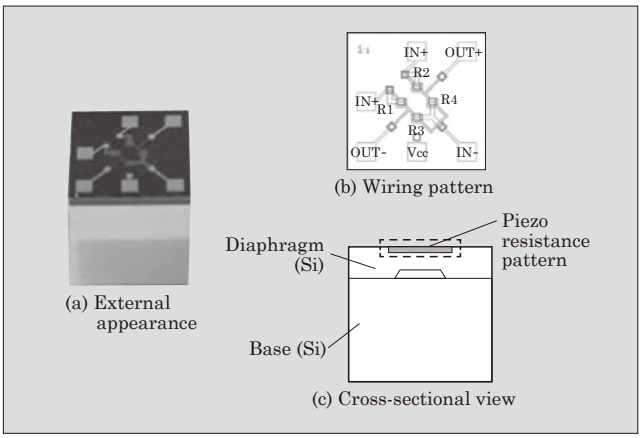

Fig.7 Piezo pressure sensor structure

Table 1 “FCX-AIV Series” lineup

Type	FKC	FKG	FKA	FKE	FKB	FKD	FKP	FKH	FKR
	 Differential pressure (flow rate)	 Gauge pressure	 Absolute pressure	 Level	 Remote seal type Pressure	 Remote seal type differential pressure (flow rate)	 Pressure (Direct mount)	 Absolute pressure (Direct mount)	 Ultra-high pressure (piezo direct mount)
Maximum span (kPa) [URL]	1 6 32 130 500 3,000	130 500 3,000 10,000 50,000	16 130 500 3,000	32 130 500	130 500 3,000 10,000 50,000	32 130 500	130 500 3,000 10,000	130 500 3,000	70,000 150,000
Mass (kg) (No indicator)	3.1	2.9	2.9	Approx. 9 to 19	Approx. 4 to 18	Approx. 9 to 19	1.8	1.8	1.5
Accuracy rating	±0.065%		±0.2%	±0.2%	±0.2%	±0.2%	±0.1%	±0.2%	±0.065%
Diaphragm material	316L SS Hastelloy-c Monel Tantalum 316L SS gold plating Gold & ceramic coating		316L SS Hastelloy-c Monel Tantalum	316L SS Hastelloy-c Monel Tantalum Titanium Zirconium 316L SS gold plating			316L SS		Inconel 625 Inconel 625 + Gold plating
Process connection dimensions	Rc 1/4			Flange standards			NPT 1/2, Rc 1/4, Rc 1/2, NPT 1/4		Autoclave F250C
Shared specifications	Span setting range: 1 to 1/100 URL Measurement period: 40 msec Temperature range (wetted parts): −40°C to +120°C (High temperature type available)*1 Ambient temperature: −40°C to +85°C Power supply voltage: 10.5 to 45 V DC Output signal: 4 to 20 mA DC				Supported communication protocol: HART Other additional specifications: Digital indicator, Degreasing, Cleaning for oxygen service*2, Chlorine measurement, Stainless steel tag plate, Local configuration function*3				

*1 FKR: −40°C to +100°C
*2 FKR: Cleaning for oxygen service not selectable
*3 FKR: Chlorine measurement not selectable

without a decline in measurement accuracy even under ultra-high pressure.

In addition, to enhance the corrosion resistance of the seal diaphragm that comes in contact with corrosive, high-pressure measuring fluids, we used inconel, a material with high mechanical stress sustainability and good corrosion resistance.

Table 1 shows the lineup of the FCX-A IV Series with the features described above.

5. Postscript

This paper described the “FCX-A IV Series” of differential and gauge pressure transmitters, which contributes to the enhancement of plant monitoring and control systems. We will continue to make efforts to expand our product lines to meet the diverse needs of our customers, thereby contributing to the advancement of more sophisticated energy saving control and automation.

References

(1) Kishiro, M. et al. FCX-AIII Series of New Type Differential Pressure/Gauge Pressure Transmitters. FUJI ELECTRIC REVIEW. 2008, vol.54, no.3, p.99-103.

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