FEATURE ARTICLE

DeviceNet™ Mass Flow Controller, the SEC-Z10D Series

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Abstract

STEC Inc. HORIBA group, has developed the SEC-Z10D Series of DeviceNet™ Controlled Mass Flow Controllers. On semi-conductor device manufacturing lines, there is an urgent need to introduce new equipment and to make devices open and shareable in order to increase productivity. The SEC-Z10D Series design is based on DeviceNet™, an open field network communications system being promoted by ODVA. In this article, we provide an introduction to the operation principle and features of the SEC-Z10D Series, and discuss the compatibility of the SEC-Z10D Series with DeviceNet™.

1 Introduction

In recent years, the semiconductor industry has been focusing their efforts on increasing the integration and density of devices, e.g., by developing 300mm wafers. On the other hand, in order to improve productivity, it is urgently required that the equipment and instrumentation are advanced to have even further functions as well as shared in their components. This trend is also seen in mass flow controllers (MFCs), which have been required not only to feature functional sophistication, wiring saving, and space saving, but to provide open architecture and high-speed communications. To meet these requirements, STEC Inc. has developed the SEC-Z10D series (Fig.1) mass flow controllers compatible with DeviceNet™, a global standard of communications system in the semiconductor manufacturing equipment.

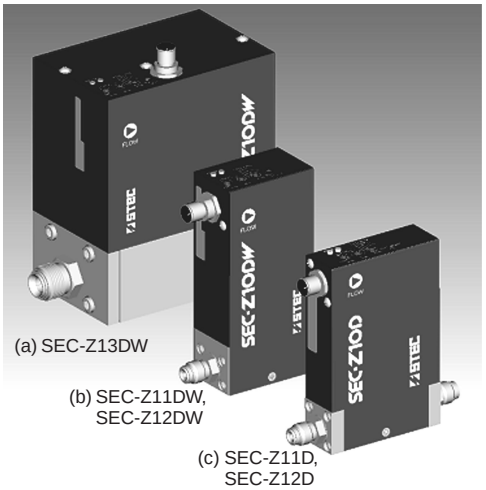


Fig.1 SEC-Z10D Series Mass Flow Controllers Compatible With DeviceNet™

2 Operating Principle and Features

An MFC mainly consists of a flow rate sensor, bypass, flow control valve, and electric circuit (Fig.2).

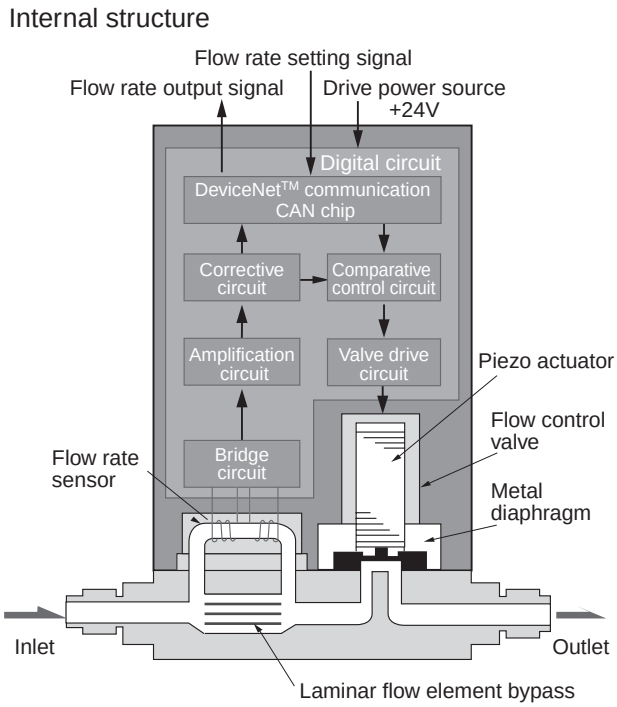


Fig.2 Structure of MFC

2.1 Flow Rate Sensor and Bypass

The flow rate sensor is structured as a stainless steel capillary that is wound with two self-heating resistors. When gas flows through the capillary, heat is removed from the upstream heating element, of which temperature declines accordingly. In contrast, heat is given to the downstream heating element, of which temperature rises accordingly. There is a certain relationship between the temperature difference and the mass flow rate of fluid. Therefore, the temperature difference is detected with a bridge circuit to obtain the mass flow rate (Fig.3). The measurement accuracy of the MFC is greatly dependent upon the diversion ratio between the flow rate in passing through this sensor and that in passing through the bypass (Fig.4). STEC uses a laminar flow element in the bypass to ensure that the sensor and the bypass have the same flow rate characteristics. This structure allows always obtaining a constant diversion ratio without being affected by the ambient temperature and operating pressure. To compensate for the flow rate, the built-in CPU processes polynomial calibration curves to achieve high accuracy in the entire range of flow rates.

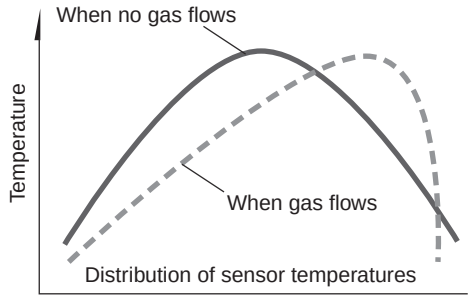


Fig.3 Detection Principle of Flow Rate Sensor

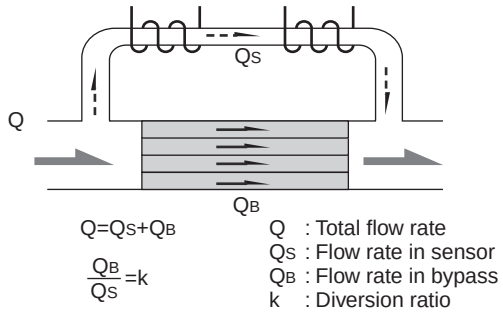


Fig.4 Diversion Ratio of Bypass

2.2 Piezo Valve

Other factors affecting the performance of the MFC include a flow control valve of which high-speed response, particle-free operation, and high stability are required. The SEC-Z10D series uses a piezo element as an actuator and a flow control valve that has a diaphragm type full-metal structure and mirror-finished surface. This minimizes the dead volume and ensures that no particles are generated from the gas-exposed section and drive section (Fig.5).

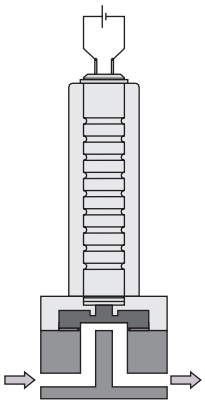


Fig.5 Piezo Type Flow Control Valve

In order to enable high-speed response in the entire range of flow rates, a quick start function has been newly adopted as standard. This function controls voltage at which the piezo valve starts being opened when the flow rate rises. In particular, the rising response performance has been improved greatly. Fig.6 shows the response characteristics of the SEC-Z10D.

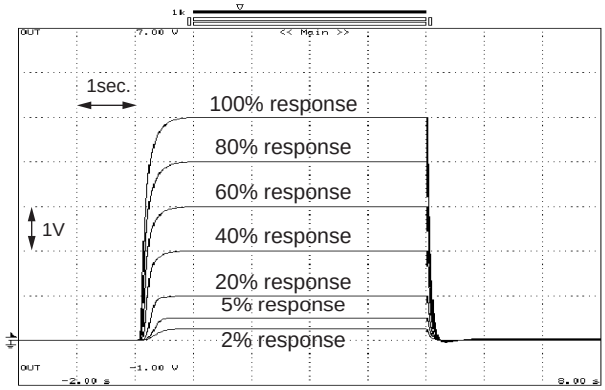


Fig.6 Response Characteristics of SEC-Z10D

3 Compatibility with DeviceNet™

The severe economic circumstances around the semiconductor industry require further cost reduction of manufacturing equipment. One of the major solutions for this requirement is to make products standardized and sharable. The SEC-Z10D series is compatible with DeviceNet™ that is established as a global standard of communications system between devices installed in semiconductor manufacturing equipment.

3.1 DeviceNet™

DeviceNet™ is a field network that is being promoted as an open global standard by Open DeviceNet Vendor Association, Inc. (ODVA). Many of the domestic and foreign semiconductor device manufacturers and the equipment manufacturers are now trying to build up their communications systems using this protocol.

The use of DeviceNet™ provides the following benefits:

1. The needs of an AD/DA converter and I/O board are eliminated to enable cost reduction and wiring saving.
2. The communications line only requires connecting the network cable and then specifying addresses. Therefore, the production line can be easily started up and the construction period can be shortened.
3. Advanced troubleshooting and maintenance can be carried out easily using the obtained data.

A special interest group (SIG) of ODVA only requires that the group 2 only server support at least I/O message. However, the SEC-Z10D series is also compatible with other transmission methods recommended in DeviceNet™ so that it can take advantage of more advanced and more diversified functions. Table 1 shows the compatibility of the SEC-Z10D series with transmission methods for DeviceNet™. Fig.7 shows a connection example of a mass flow controller compatible with DeviceNet™.

Communication using DeviceNet™

- Master/slave communication
  - I/O message ○
  - General transmission method (parent→child) ○
  - Transmission occurs when state changes (child→parent) ○
  - Transmission occurs at cyclic time (child→parent) ○
  - Broadcast occurs from parent station to child stations (parent→child)
    Transmission occurs in response to broadcast (child→parent) ○
- Peer-to-peer communication
  - Explicit message ○

The mark ○ indicates that this function is available in the SEC-Z10D series.

Table 1 Compatibility of SEC-Z10D with Transmission Methods in DeviceNet™

* Some of the lecture information at the ODVA JAPAN DeviceNet™ seminar is cited.

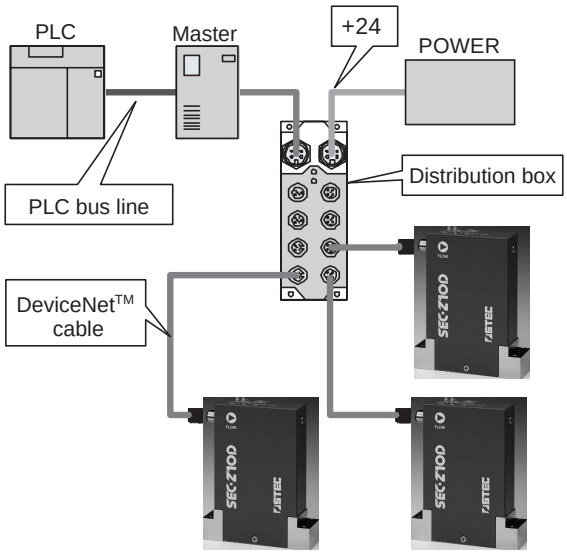


Fig. 7 Example of Network Buildup UsingSEC-Z10D DeviceNet™

3.2 Open Network Test

The SEC-Z10D series passed various functional tests conducted by third-party organizations, which verified its high functionality and performance.

(1) Odva Conformance Test

This test was conducted by ODVA to evaluate the conformance to the specification of DeviceNet™. The result showed that the SEC-Z10D series was highly compatible with other products.

(2) ODVA Semi SIG Test

This test is regarded as being at an upper level of the ODVA conformance test. The devices that passed this test were demonstrated as gaining satisfaction from the customers in the semiconductor industry.

(3) Texas A&M University Marathon Test

This is a long-term stability test conducted by the automation research institute of Texas A&M University. The result of this test demonstrated high quality of the SEC-Z10D series.

4 External Dimensions

In the past, joints of the common type (VCR type) were used to connect the components of the gas supply system in the semiconductor process. Recently, the integrated gas system (IGS) has been increasingly used, in which the components are directly connected to each other on the common base block (Fig.8).

Under the market circumstances, the SEC-Z10D series include products with width of 1.125inch as the SEC-Z10D series and those with width of 1.5inch as the SEC-Z10DW. Fig.9 shows the external dimensions of the SEC-Z10D series.

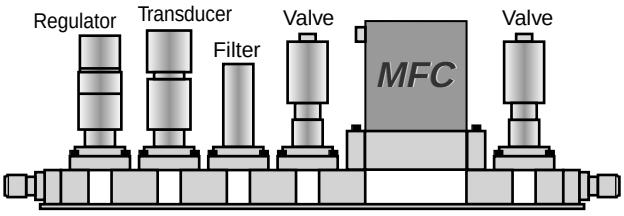
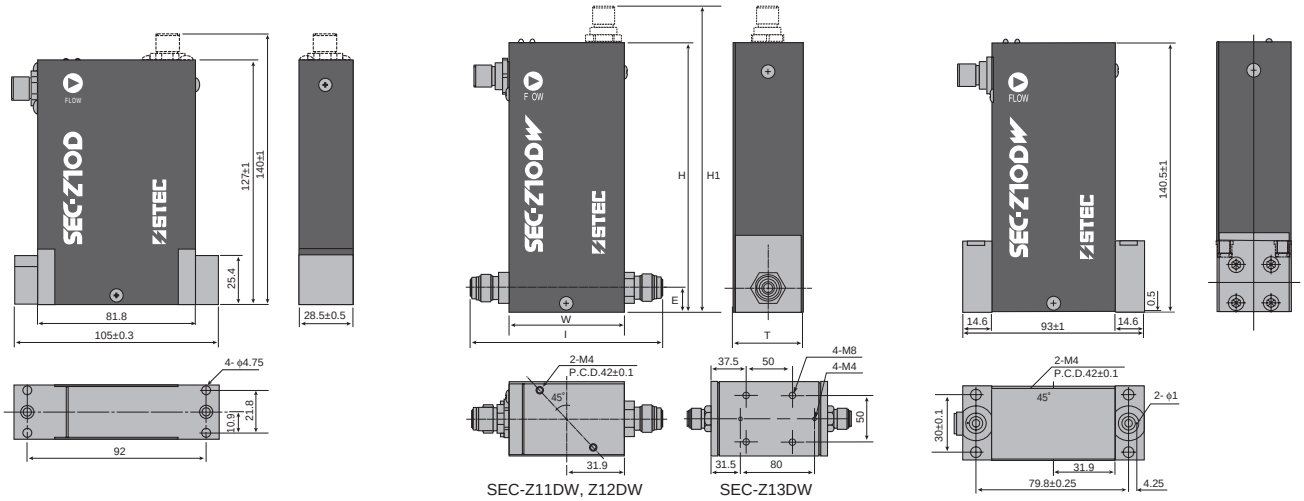


Fig.8 Integrated Gas System (IGS)



	A	T	W	H1	E	I
SEC-Z11DW SEC-Z12DW	140±1	38.6±0.5	63.8	159±1	12.7	106±1*1
SEC-Z13DW	155±1	80±0.5	125	172±1	20	177±1*2

*1: Equivalent to 1/4 VCR *2: Equivalent to 3/8 VCR

Fig.9 External Dimensions of SEC-Z10D Series

5 Conclusion

Semiconductor manufacturing equipment and parts will be made more sophisticated and shareable at an accelerating pace in order to achieve higher productivity. STEC has earlier responded to these needs to commercialize the SEC-Z10D MFCs, which should be useful for customers. The semiconductor industry is daily changing and always requires us to stay updated. We hope that this article will help open up closer communication with customers so that we can comply with true needs.

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