Development of Control Circuit Board for Auto-Tuning Vacuum Capacitor (Auto-VC)

Yuichi Nishikiori,
Koji Kawashima,
Yoshiyuki Tanimizu

Keywords Vacuum capacitor, Semiconductor manufacturing equipment, EtherCAT, Motor configuration

Abstract

Vacuum Variable Capacitor (VVC) is mainly used for impedance matching in semiconductors and Flat Panel Display (FPD) manufacturing equipment such as Chemical Vapor Deposition (CVD) equipment and etching equipment. The Auto-tuning Vacuum Capacitor (Auto-VC) is a motorized VVC used as a module that integrates the VVC, drive motor, and connecting part, and can specify the capacitance with high accuracy (±0.5%) using an attached dedicated controller. Since September 2014, the Auto-VC has been mass-produced and is supplied mainly to equipment manufacturers and power supply manufacturers.

The Auto-VC equipped with an absolute position detecting function eliminates the need to take a mechanical origin reset action that is formerly required at the time of starting, allowing the equipment to start more quickly.

The EtherCAT-compliant Auto-VC achieves a significant increase in communication speed compared to conventional communication speeds, enabling connections with a high degree of freedom.

1 Preface

The capacitance of the Vacuum Variable Capacitor (VVC) is set by rotating the shaft in the middle of the main unit. When incorporating a VVC into equipment, the structural design matters, such as the design of the rotary shaft drive mechanism, and the withstand voltage of the connecting part, and mechanical strength. A control circuit for controlling the drive mechanism and an interface circuit with a control device were required, which made the development cost high and difficult to create a highly reliable system.

The Auto-tuning Vacuum Capacitor (Auto-VC) integrates these important parts and modularizes the drive mechanism, control circuit, and external interface. This paper introduces a new product lineup, the Auto-VC equipped with an absolute position detecting function, and the Auto-VC compatible with EtherCAT.

2 Features

2.1 Features of Auto-VC

The connection between the motor and VVC must satisfy many requirements, such as structural strength, withstand voltage performance, assembly accuracy, and durability. Many challenges present in meeting such requirements. As such, development requires a reasonable amount of cost and time.

Fig. 1 shows the configuration of the Auto-VC. It consists of a motor, an insulated coupling, and a dedicated controller necessary for variable control of VVC and capacitance. Trouble countermeasures

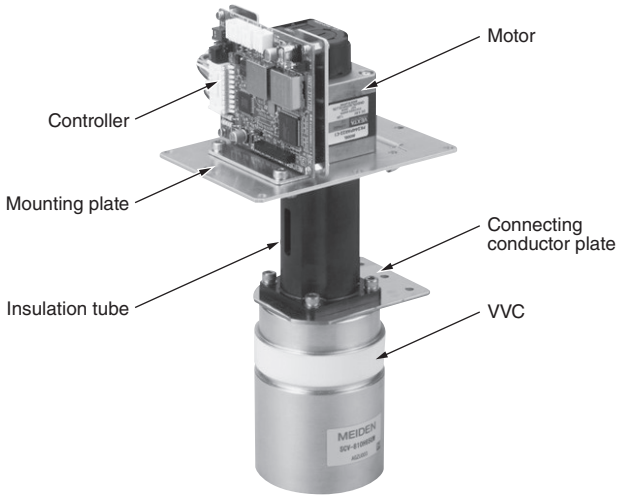

Fig. 1 Configuration of Auto-VC

Mounting plate and connecting conductor plate can be customized.

developed over many years are reflected in each part achieving high reliability. In addition, since the elements to control capacitance is a module, it can be easily installed without complicated construction work.

In addition, the shape of the mounting plate and connecting conductor plate on the motor side can be customized according to the specifications. This satisfies a wide range of customer needs.

2.2 Auto-VC with Absolute Position Detecting Function

Fig. 2 shows the structure of the Auto-VC. A stepping motor is used as the drive mechanism. Since the stepping motor rotates according to the input pulses, the rotational position can be controlled by controlling the number of input pulses. When a torque greater than the output torque of the stepping motor is applied, however, a phenomenon called “loss of synchronism” occurs, in which the relationship between the number of input pulses and the rotational position deviates. In general, a large motor that does not cause the loss of synchronism and has a margin of output torque is used.

The Auto-VC uses a stepping motor with a rotary encoder. By checking the rotational position with a rotary encoder, it is possible to correct the rotational position in the event of a loss of synchronism, making it possible to use a compact, high-efficiency motor with low output torque.

When controlling the rotational position with a motor, it is necessary to set a position that serves as the control origin. In the conventional Auto-VC, the axis was rotated to the mechanical origin, and the stop position was used as the control origin. In order to operate the machine to the mechanical origin each time the Auto-VC power is turned on, it is necessary to allow an error in the mechanical origin, which complicates the start-up sequence of the equipment.

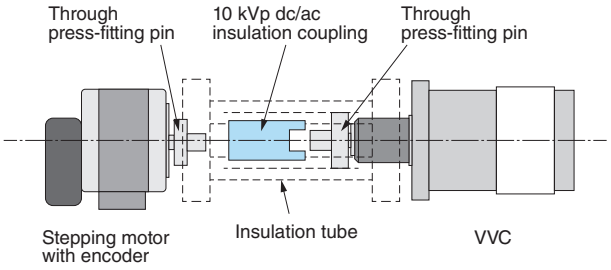

Fig. 2 Structure of Auto-VC

The driving mechanism uses a stepping motor.

To solve these challenges, we added to our lineup, an Auto-VC equipped with a new absolute position detecting function.

2.3 EtherCAT-Compliant Auto-VC

A serial communication system (RS485) was adopted for a communication interface in the conventional Auto-VC, with a communication speed of 9600 bps and a maximum of 16 units per line.

In recent years, in the field of semiconductor manufacturing equipment, Ethernet-based communication interface for high-speed communication lines has been included in the required specifications of mounting equipment. Among them, EtherCAT is a field network that is characterized by real-time performance and is rapidly spreading.

This time, as a communication interface, an EtherCAT-compliant Auto-VC has been added to the lineup. By adopting EtherCAT, a communication speed of 100 Mbps has been achieved. This resulted in a significant increase in speed. The maximum number of connections per line is the maximum number of all EtherCAT devices connected. In addition, various devices conforming to the EtherCAT standard can be connected to the same network. This enables us to build networks with a dramatically higher degree of freedom than ever before. Fig. 3 shows the construction of an Auto-VC network by EtherCAT.

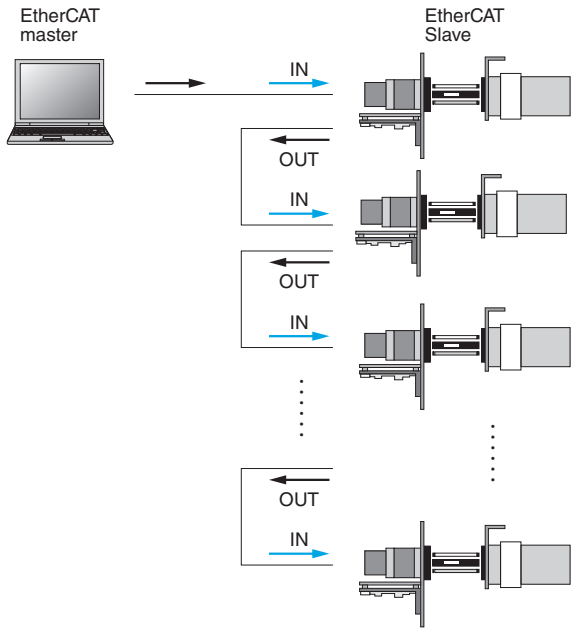

Fig. 3 Construction of Auto-VC Network by EtherCAT

A network with a high degree of freedom can be easily constructed.

Fig. 4 Auto-VC with Absolute Position Detecting Function

An absolute position detecting function is provided.

Fig. 5 EtherCAT-Compliant Auto-VC

This type of Auto-VC is applicable to EtherCAT communication.

3 Product Introduction

3.1 Dedicated Auto-VC Controller with Absolute Position Detecting Function

Fig. 4 shows the Auto-VC with absolute position detecting function. This product can confirm the absolute position. This function eliminates the need to search for the machine origin when the power is turned on. In addition, since it uses the same RS485 communication system as the communication interface, developers who deal with conventional products can easily introduce it.

3.2 EtherCAT-Compliant Auto-VC Dedicated Controller

Fig. 5 shows an EtherCAT-compliant Auto-VC. Equipped with an EtherCAT function, it operates as an EtherCAT Slave and performs control related to capacitance setting via EtherCAT communication.

In addition to the EtherCAT communication port, it has a serial communication (RS485) communication port. For this reason, even at development sites where it is difficult to maintain an EtherCAT environment, operation can be easily confirmed using serial communication. The EtherCAT-compliant Auto-VC controller also supports the absolute position detecting function.

4 Postscript

As a new lineup of Auto-VC, we introduced an Auto-VC with an absolute position detecting function and an EtherCAT-compliant Auto-VC. Currently, we are developing another type of Auto-VC that uses high-speed communication by EtherCAT, which is compatible with the Auto-VC, to shorten the time required to change the capacitance and to achieve high-precision setting values.

In the future, we intend to work on the development of products with even higher added value.

Lastly, we would like to express our deepest gratitude to everyone involved with this product development for your great cooperation.