EcoMonitorPlus Extension Model for Analog/Pulse Input

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Production sites increasingly need to reinforce energy-saving measures and introduce predictive maintenance. We have developed an Analog Input Unit and Pulse Input Unit as extension units of the EcoMonitorPlus energy measurement unit. The Analog Input Unit is capable of receiving analog signals from various sensors (temperature, vibration, etc.). The Pulse Input Unit measures pulse signals that convey the production quantity, flow rate of water and air, etc.

1. Overview of the Analog/Pulse Input Units

1.1 Product specification

Table 1 shows the main specifications of the Analog Input Unit and the Pulse Input Unit. Both have been added to the product line as extension units for the following purposes: the Analog Input Unit is for customers who want predictive maintenance based on measuring temperature and vibration of equipment; and the Pulse Input Unit is for customers who need to measure production quantity and flow rate of water and air, etc. Measurements can be made with the optimum configuration for the object being measured through the combination with EcoMonitorPlus (Table 2), which is already placed in the market. The entire system can be extended according to changes in measurement needs by the adding units (Fig. 1).

1.2 Product concept

(1) Implementing energy management and predictive maintenance with one unit

In the conventional EcoMonitorPlus systems,

Table 1 Specifications of the Analog Input Unit and Pulse Input Unit

Item			Specifications	
Model			EMU4-AX4 (Analog Input Unit)	EMU4-PX4 (Pulse Input Unit)
Input specifications	No. of inputs		4	
	Input signal format		Differential input (0 V to +5 V; 0 mA to 20 mA)	Non-voltage a-contact
	Insulation type		Photocoupler insulation	
	Rated voltage/current		Voltage: 0 V to +5 V (Input resistance: 1 MΩ) Current: 0 mA to 20 mA (Input resistance: 250 Ω) Note: The input range (voltage/current) can be changed. (To be changed for each CH in some settings.)	6.5 V DC, 10 mA (supplied from the main unit)
	Input pulse conditions		–	Pulse ON time: 30 ms or more OFF time: 30 ms or more
	Measuring object[1]		AD conversion value, scaling value, number of times the limit is exceeded	Pulse input: Pulse count, pulse conversion Contact input: operation time, contact status * External input (pulse input/contact input) can be changed. (To be changed for each CH in some settings.)
	Range of measurement values [1]		AD conversion value: 0 to 4095 Scaling value: -32767 to +32767	Pulse count: 0 to 999,999 Pulse conversion: 0.001 to 999,999,000
	Accuracy		AD conversion value: ±1.0% (23°C ± 10°C) of input rating	–
	Data update cycle		1 ms x No. of channels; 50 ms x No. of channels	–
Output specifications	Output signal format		Non-voltage a contact 1 output	
	Function	Warning item	Scaling value upper/lower limit; Scaling value upper limit; Scaling value lower limit	Pulse conversion upper limit
	Rated switching voltage/current		35 V DC; 75 mA, or 24 V AC; 75 mA (power factor 1)	
	Insulation type		Semiconductor relay insulation	
External dimensions (unit: mm)			37.5(W) x 90(H) x 92.9(D) (excluding protrusions) (Maximum dimensions including protrusions: 41.5(W) x 99(H) x 92.9(D))	
Compliant with			CE marking (EMC: EN61326-1: 2013, Safety: EN-61010-1: 2010), UL: UL61010-1	

1 Measurement details of each object
- AD conversion value: Value obtained by converting an input analog value into a digital value from 0 to 4095. (Example: "0°C to 100°C" is converted to "0 to 4095.")
- Scaling value: Value obtained by converting an AD conversion value into a value on a different scale. (Example: "0 to 4095" is converted to "0°C to 100°C".)
- Number of times level exceeded: Value obtained by counting the number of times exceeding a set threshold value. (See 3(2) in the article.)
- Pulse count: Value obtained by counting the number of input pulses.
- Pulse conversion: Value obtained by converting the number of input pulses into a value on a different scale. (Example: Converted to the quantity of water used.)
- Operating time: Value obtained by integrating the time when a contact is turned ON (input). (Example: The equipment operating time is measured by contact input of equipment operation statuses.)
- Contact state: State of a contact if it is input or not (ON/OFF).

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Table 2 List of EcoMonitorPlus Products

Category	Product name	Model number
Base unit	Energy Measuring Standard Model	EMU4-BM1-MB
	Energy Measuring High Performance Model	EMU4-HM1-MB
	Insulation Monitoring Model	EMU4-LG1-MB
Extension unit	Extension Model for Same Voltage System	EMU4-A2
	Extension Model for Different Voltage System	EMU4-VA2
	Analog Input Unit	EMU4-AX4
	Pulse Input Unit	EMU4-PX4
Option unit	Logging Unit	EMU4-LM
	CC-Link Communication Unit	EMU4-CM-C

predictive maintenance against load current and leak current is available by measuring quantity of electricity in addition to energy management by efficiently using information on the amount of electric power, etc. However, in some failure modes, it is difficult to identify a predictor of failure only by measuring the electricity quantity, and information on vibration, temperature, etc. may be required. Therefore, the new Analog Input Unit for receiving analog signals from various sensors was added to the EcoMonitorPlus extension unit line. With the Analog Input Unit, the EcoMonitorPlus predictive maintenance can now use information on vibration, temperature, etc., not only the measured electricity quantity.

(2) Measuring the electricity quantity, flow rate, and production quantity by using one unit

EcoMonitorPlus systems have only a pulse signal input to the base unit (high functionality unit) and cannot receive multiple pulse signals such as signals on the production quantity and flow rates (water and air). Therefore, the new Pulse Input Unit for receiving pulse signals was added to the EcoMonitorPlus extension unit line, enabling EcoMonitorPlus systems to measure the electricity quantity, flow rates (water and air), production quantity, and other equipment information.

2. Features of the Products and Technology Used for the Products

2.1 Sampling period and communication time for analog signals

(1) Issues in collecting analog values

The sampling periods of the Analog Input Unit have been set to 1 ms in order to detect any abnormality by vibration sensor (displacement and speed).

However, missing data may occur due to insufficient time for communication; as the conventional EcoMonitorPlus responds with the current value to a request, the host system needs to collect data for each sampling period within the communication time of 76 ms required for data collection in 1 ms (Fig. 2).

(2) Measures by changing the data collection method

Data for 1 ms cannot be collected by the conventional method that collects one data item per message due to restrictions on communication time. To solve this, by transmitting and receiving multiple MODBUS RTU data at one time, we have designed the Analog Input Unit to process batch transmission and reception of data for 100 ms saved in the Analog Input Unit. This allows 100 ms of data to be collected in 71 ms and analog values to be collected without any lack (Fig. 3).

2.2 Analog signal threshold monitoring method

Since analog signals measured by various sensors vary greatly within a short cycle, the upper/lower limits with simple thresholds lead to repeated warning and recovery messages, and cannot correctly determine an abnormal equipment state. Accordingly, in addition to the upper/lower limits originally used, we have designed the Analog Input Unit to count the number of occurrences exceeding the threshold and also the number of times exceeding the predetermined number of occurrences (number of times exceeding the limits). This function has four-stage upper/lower limits (levels) from A to D. For each limit, the

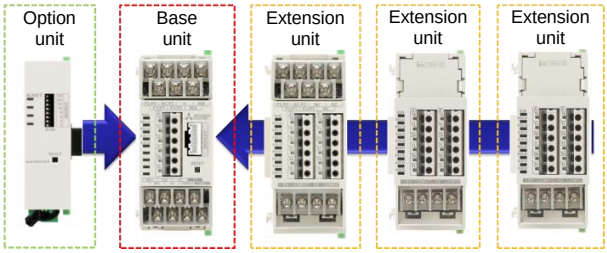

Fig. 1 How to extend an EcoMonitorPlus system

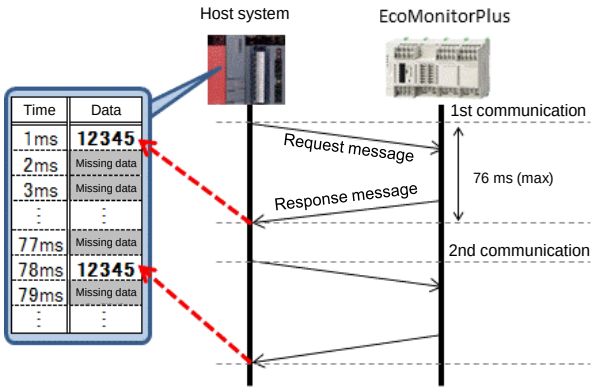

Fig. 2 Communication in 1 ms periods (conventional)

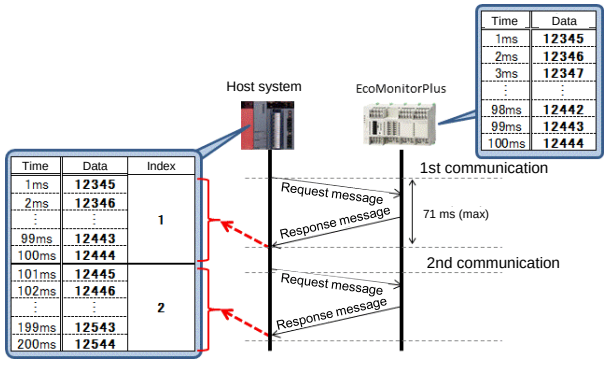

Fig. 3 Communication in 1 ms periods (Analog Input Unit)

number of exceeding times is counted. By detecting occurrences when the limit has been exceeded the specified number of times, the equipment conditions can be managed in the four stages (for example, A: Caution; B: Alert; C: Maintenance; and D: Equipment renewal), facilitating systematic equipment maintenance (Fig. 4).

3. Example of e-F@ctory Collaboration

3.1 Working with programmable controllers

Using EcoMonitorPlus and a programmable controller, energy saving and productivity can be improved by specific energy consumption management, and predictive maintenance for the equipment can also be performed. For the communication of various programmable controllers using the MODBUS RTU communication function that comes standard with the Analog Input Unit, function blocks are provided so that users can create ladder programs more quickly. (The function blocks can be downloaded free of charge from the Mitsubishi Electric FA site.)

(1) Specific energy consumption management

Based on the energy information (quantity of electricity/flow rate) measured using EcoMonitorPlus and the production information (production quantity, equipment operation status, etc.) in the programmable controller, waste can be found by the specific energy consumption management. For example, if a significant amount of energy is consumed in a time zone that involves no production operation, waste can be reduced by revising the production phases or turning the equipment power off when there is no production operation to perform (Fig. 5).

(2) Predictive maintenance

In predictive maintenance using current and temperature information, as the measurement values vary depending on the production items and the operating conditions of the equipment, determining an abnormal value is difficult with only measurement values. Instead, monitoring is performed in combination with production information (production items, equipment operation status, etc.) obtained from the programmable controller. This allows the measurement values to be compared with those when the same production items are produced, and also under the same conditions at different times (for example, at the time of launching the equipment). Thus, predictive maintenance of the equipment can be implemented (Fig. 6).

3.2 Working with Graphic Operator Terminals

By communicating with a Graphic Operator Terminal (GOT) using the MODBUS RTU communication function that comes standard with the Analog Input Unit, energy can be visualized and saved, and various types of analog signals can be visualized for predictive maintenance. We provide samples of the visualization screens. (Samples

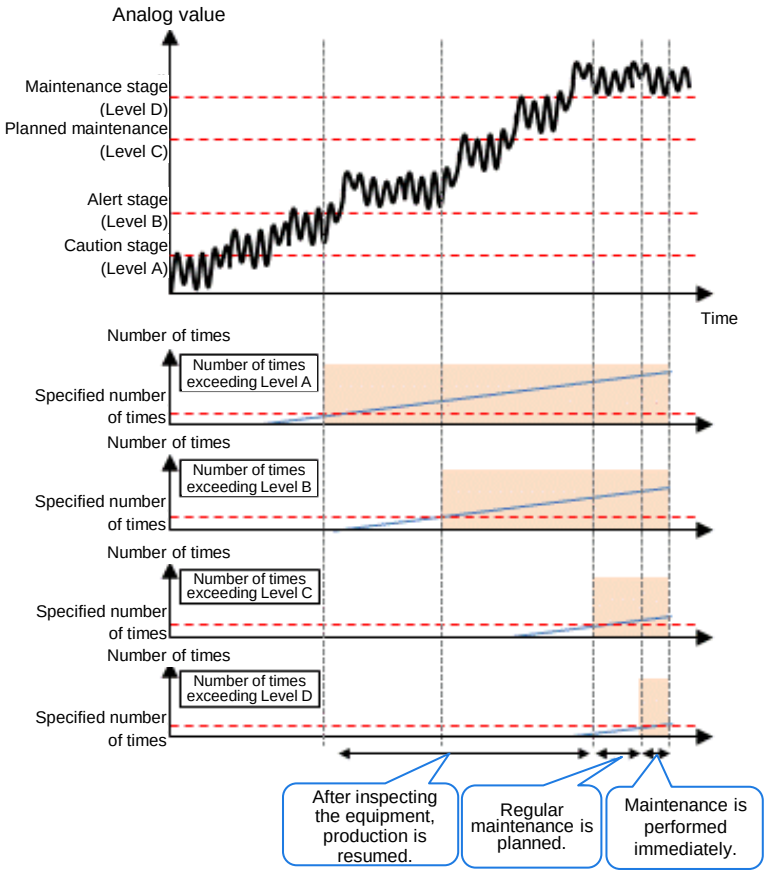

Fig. 4 Example of the number of times exceeding the limits

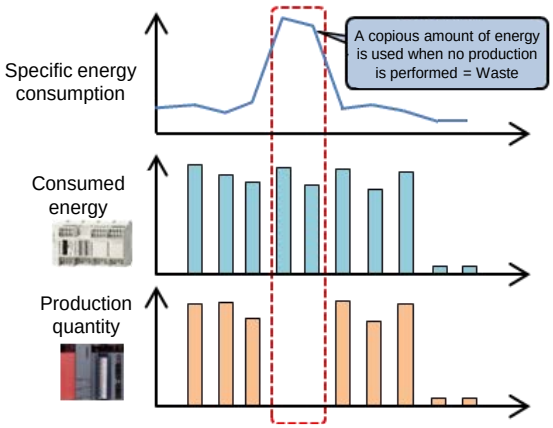

Fig. 5 Improvement based on energy information and production information

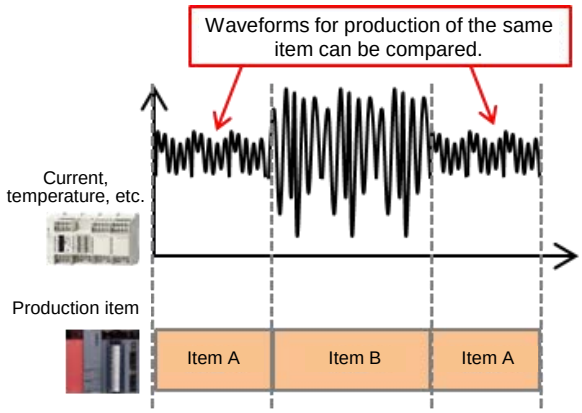

Fig. 6 Predictive maintenance based on analog signals and production information

can be downloaded free of charge from the Mitsubishi Electric FA site.)

4. Conclusion

This article has described the Analog Input Unit and the Pulse Input Unit developed as extension units of EcoMonitorPlus, an energy measuring unit that can be extended by adding units. While improving the functionality of these products and reinforcing the product line, we will continue developing energy measuring units that help customers save energy and perform predictive maintenance.

References

(1) Yasunori Matsuoka: Energy measuring unit "EcoMonitorLight," Mitsubishi Denki Giho, Vol. 88, No. 4, 269–272 (2014).
(2) Tetsushi Narui: Energy measuring unit "EcoMonitorPlus," Mitsubishi Denki Giho, Vol. 90, No. 4, 247–250 (2016).