

Development of Power Supply Condition Monitoring Technology

Ryo Koshiya,
Yasuyuki Iwauchi,
Yoshihiro Hasegawa

Keywords Power supply, Condition monitoring technology, Preventative maintenance, Condition based maintenance

Abstract

For industrial machines, preventative maintenance done before the occurrence of a failure is essential. Time Based Maintenance (TBM) is currently the mainstream in precautionary maintenance, while Condition Based Maintenance (CBM) has begun to attract attention due to the development of data sensing technology and the social demand to lower maintenance costs and improve reliability. In many cases, among various machines and equipment, the power supply unit is equipped with service for life-limited components and parts and Condition Based Maintenance is required.

Against this background, we developed a power supply condition monitoring technology that utilizes data sensing technology, and also developed a prototype of a power supply system adding a condition monitoring function.

1 Preface

We offer a variety of industrial computers, switching hubs, and related apparatus and equipment. Industrial machines are required to assure many years of stable operation. To meet these requirements, it is essential to perform preventative maintenance for equipment.

Preventative maintenance formerly was done in the form of Time Based Maintenance (TBM) for which maintenance is performed at the intervals of the specified period. In recent years, however, sensing technology using sensors, and communication network advance has led to the development of Condition Based Maintenance (CBM) which has attracted a lot of attention.

CBM is a maintenance approach for which equipment conditions are continually monitored. When any sign of malfunction is revealed, the necessary maintenance is carried out according to the detected equipment conditions.

In order to estimate the life of the machine and determine maintenance times, the maintenance intervals are shorter than the actual life of the machine. It is too costly to have a fixed term. In TBM, maintenance timing is determined by predicting the remaining equipment life under projected worst case conditions of use. Accordingly, maintenance timing is determined for a shorter life period

than the actual life span and is wasteful. On the contrary, CBM is carried out upon the discovery of a sign of equipment malfunction. Such an approach inevitably can lower unnecessary maintenance costs and equipment availability can be improved for better facility management.

We are promoting the development of products in support of CBM. We produced and evaluated a prototype of a power supply unit where a condition monitoring function is incorporated. In many cases, since the power supply unit is an indispensable component for all equipment, and it is equipped with an aluminum electrolytic capacitor which is a life-limited serviced component, its need for conditional monitoring is high. This paper introduces this newly developed power supply condition monitoring technology.

2 Outline of Power Supply Unit with Condition Monitoring Function

A prototype of a duplex power supply unit (“this power supply unit” hereafter) was manufactured and comes with a condition monitoring function used for our industrial switching hub, MEIWAY SW900. Fig. 1 shows the system configuration of the developed power supply unit and Table 1 shows its specifications. Using the installed microcomputer, temperature and voltage data acquired from the

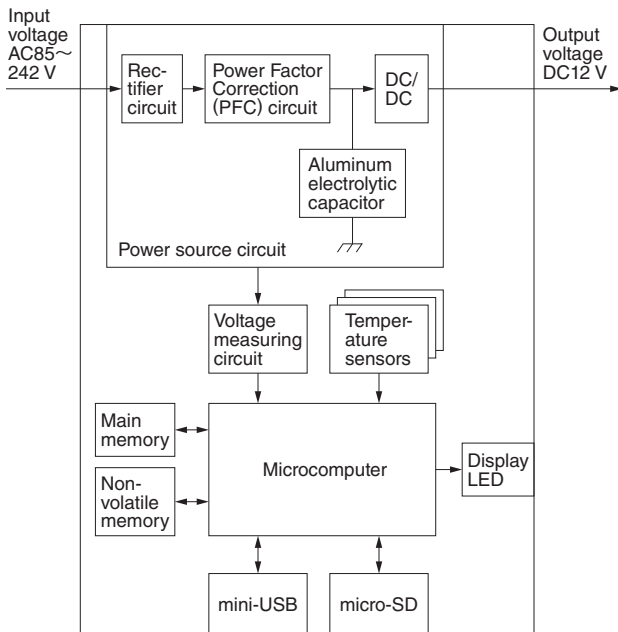


Fig. 1 System Configuration of Developed Power Supply Unit

Using the installed microcomputer, temperature sensors, and voltage measuring circuit, conditions of the power source are monitored.

Table 1 Specifications of Developed Power Supply Unit

Specifications are equivalent to those of the SW900. As an external interface to acquire condition monitoring data, a mini-USB and micro-SD are loaded.

Item	Specifications
Power source connector	3P inlet type
Input voltage range	AC85~242 V
Rated output voltage	DC12 V
Rated output power	50 W
Operating temperature range (during operation)	-10~55°C
Withstanding voltage (Power source Primary-Secondary)	AC2000 V for 1 minute
Insulation resistance (Power source Primary-Secondary)	DC500 V 5 MΩ or more
Power source noise durability	Rectangular impulse noise 2 kV, 50 ns/1 μs
Mass	Approx. 1.5 kg
External dimensions	W160 × H50 × D300 mm (Embossed parts excluded)
External interface	mini-USB × 1 micro-SD × 1

respective sensors are gathered and used to monitor the conditions in the power supply. The acquired data can be obtained via a mini-USB or micro-SD.

3 Power Supply Condition Monitoring Technology

3.1 Object of Condition Monitoring

A capacitor used in the smoothing circuit of the power supply is a large capacity and high voltage resistance. In many cases, aluminum electrolytic capacitors are used. The aluminum electrolytic capacitor is subject to the reduction of its capacity as a result of electrolyte evaporation.

In other words, it is a life service-limited component which deteriorate over time. The deterioration of an aluminum electrolytic capacitor, which is used as the smoothing capacitor, can cause malfunctions such as an increase in ripple voltage, instability of power source output, and output stoppage. Such a malfunction can lead to maloperation of equipment and functional stoppage. For this reason, we decided on this type of capacitor for condition monitoring.

3.2 Condition Monitoring Function

Three types of condition monitoring functions have been provided to this power supply unit. Fig. 2 shows an example of CBM application of each monitoring function.

3.2.1 Estimated Lifetime Calculating Function

For the aluminum electrolytic capacitor, its deterioration speed can differ according the operating conditions such as ambient temperature and applied voltage level. Ambient temperature, in particular, can be a major cause.

The estimated lifetime under each operating condition can be obtained by Arrhenius' lifetime computation formula. In order to attain highly accurate lifetime estimation, however, it is necessary to perform computation based on actual conditions of use. For this power supply unit, we therefore used a temperature sensor and a voltage measuring circuit in order to measure the ambient temperature and applied voltage for the aluminum electrolytic capacitor. This unit is provided with a function to calculate the estimated lifetime under actual operating conditions.

The temperature sensor is mounted the aluminum electrolytic capacitor. High-accuracy temperature measurement can be conducted by making adequate amendment of measured data. Through the measurement of temperature and applied voltage during a determined period, it is possible to make lifetime estimation in accordance with varia-

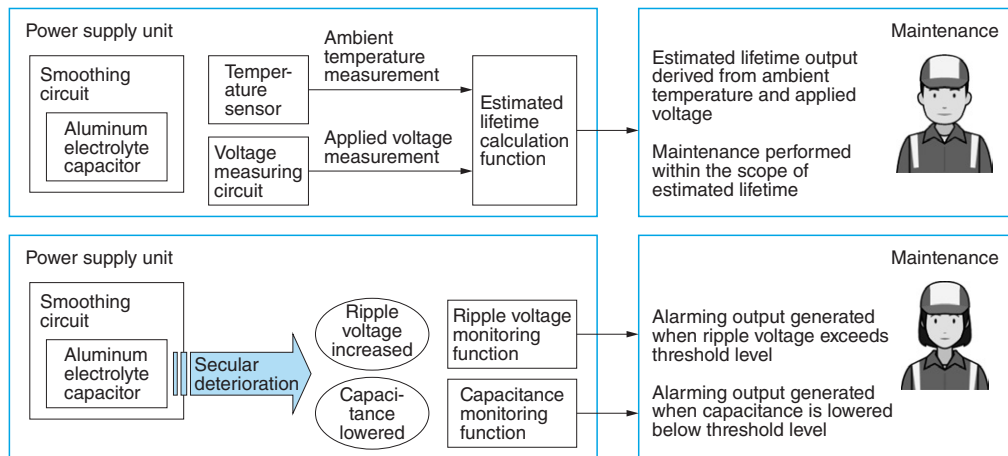


Fig. 2 Example of CBM Application

Estimated lifetime is calculated based on ambient temperature and applied voltage. Based on ripple voltage and capacitance acquired from the data output, an alarming sound output is generated.

tions in operating conditions.

3.2.2 Ripple Voltage Monitoring Function

If deterioration is caused in an aluminum electrolytic capacitor of the smoothing circuit, an equivalent series resistance becomes high and ripple voltage is increased. Since this power supply unit is provided with a voltage ripples monitoring function, an alarm sounding function is available when the measured ripple voltage exceeds the threshold level of the error judging criterion. For ripple voltage measurement, measuring accuracy can be improved by making a filter adjustment in the voltage measuring circuit.

3.2.3 Static Capacity Monitoring Function

Since the aluminum electrolytic capacitor accompanies the lowering of capacitance due to deterioration over time, the rate of deterioration can be monitored by monitoring the capacitance. Utilizing this factor, this power supply unit is provided with a capacitance monitoring function. While the power supply is turned off, the discharge time of the aluminum electrolytic capacitor is measured by a microcomputer so that the capacitance can be calculated based on the measured discharge time. If the calculated capacitance exceeds the threshold level of the error judgment criterion, the occurrence of a failure is notified by sound alarming.

3.2.4 Comparison of Condition Monitoring Functions

Table 2 shows a comparison of three types of condition monitoring functions. Although the estimated lifetime calculating function is based on indirect monitoring of deterioration, it has the advantage

Table 2 Comparison of Condition Monitoring Functions

Advantages and disadvantages of the respective condition monitoring functions are shown.

Condition monitoring function	Advantages	Disadvantages
Estimated lifetime calculation function	• Remaining lifetime clear	• Indirect monitoring (Estimated lifetime)
Ripple voltage monitoring function	• Direct monitoring of deterioration	• Remaining lifetime unclear
Capacitance monitoring function	• Direct monitoring of deterioration	• Remaining lifetime unclear • Detection is enabled only if the power source is OFF

that the estimated lifetime can be made concisely. While in the case of other two types of condition monitoring functions, the lifetime cannot be estimated accurately. These two functions, however can detect variations in ripple voltage and capacitance resulting from deterioration. Accordingly, deterioration in objective components and parts can be monitored directly and the related information can be reported before the occurrence of equipment failure. If these three types of condition monitoring functions are used in combination, condition monitoring becomes possible with higher reliability.

3.2.5 Graphical User Interface (GUI)

Fig. 3 shows a GUI screen that displays the current conditions being monitored. Connected with a Personal Computer (PC) through mini-USB, the estimated lifetime, ripple voltage, and capacitance of an objective capacitor are displayed.

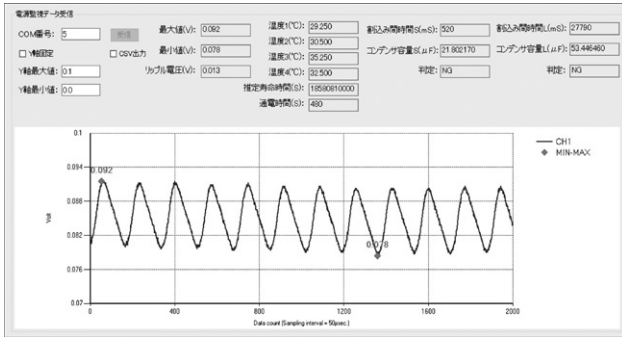


Fig. 3 GUI Screen

It is possible to examine the estimated lifetime of aluminum electrolytic capacitor, capacitance, and applied ripple voltage.

4 Postscript

This paper introduced the outlined features of our power supply condition monitoring technology developed for the CBM of industrial equipment. When this expertise is applied to regular monitoring of power supply conditions, the maintenance cost can be reduced by extending the maintenance cycle. It also prevents the loss of function due to power failure of the equipment. In doing so, it can improve the reliability of the system.

In the future, we will utilize condition monitoring technology to reduce maintenance costs and produce the product with high reliability.

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