Development of automatic processing system for contact loss signal

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Abstract

The contact loss between pantographs of electric rolling stock and contact wire is used to grasp structures of overhead line equipment and current collecting quality. Since the contact loss is mainly evaluated by the contact loss rate and contact loss times, it is necessary to process contact loss signals. Until now, we have used a waveform processing software developed by RTRI, which requires to reproduce data once again after field tests by consuming much time and labor. Therefore, we have developed an automatic processing system for contact loss signals which can detect contact loss on a real time basis and automatically calculate the contact loss rate, the contact loss duration times, etc. From field tests, we have confirmed that this system has the same performance processing contact loss as the former system has.

1 Introduction

The contact loss between pantograph and contact wire, which is measured by commercial trains or inspection cars, is used to grasp the current collecting quality. Although there are a number of contact loss measuring systems, we use mainly a contact loss measuring device using pantograph currents or an optical contact loss measuring device using arc light which is generated at the occurrence of contact loss. The contact loss signals measured in field tests are usually totaled per drum (the section between two overlaps) to
calculate the contact loss rate and the number of contact loss occurrence and those data are
expressed as speed characteristics. Until now, we have to perform A/D conversion and
process the data for every drum by using the waveform processing software after tests, so
we have been very busy since we have to repeat measurement. Therefore, we have
developed an automatic data processing system for contact loss signals [1] which can
detect contact loss on a real time basis and automatically calculate the contact loss rate, etc.
from input pantograph-collecting current signals and contact loss signals measured by arc
light. We can use this system by easy switch operation and set up on a Windows screen,
so that we can increase the efficiency of contact loss measuring work.

2 Creating of automatic processing system for contact loss signal

This time, we have developed a system for Shinkansen and created a contact loss
processing system by AC current and optics, which are generally used in the field tests for
Shinkansen.

2.1 Contact loss measuring system

Figures 1 and 2 show an outline of contact loss measuring systems. Figure 1 shows the
measuring system by AC current, and Figure 2 that by optics. The first system is to
detect that the current collected by one pantograph becomes zero when two or more
pantographs are connected by an extra high voltage bus on AC current rolling stock. The
second system is to detect arc light when a pantograph separates from the contact wire.

2.2 Outline of automatic processing system for contact loss signal

We developed the automatic processing system for contact loss signals under the following
conditions.
(1) As input signals, this system can process two channels of pantograph current, two
channels of contact loss signal by measuring arc light, main transformer current, running
speed signal, drum signal and change-over section signal.
(2) This system can output the contact loss rate, the contact loss duration time and the
number of contact loss occurrence for each input signal.
(3) This system can calculate contact loss characteristics on a real time basis and can
display the results immediately.
(4) This system can save the calculated data for analysis after field tests.
To meet these requirements, we have developed the system as a hybrid system, which
detects contact loss from the pantograph current by hardware and calculates the contact
loss characteristics by software. Figure 3 shows the composition of this system.
Figure 1: Measuring system by AC current

Figure 2: Measuring system by arc light

Figure 3: Composition of automatic processing system for contact loss signal
2.3 Contact loss detection device by AC current

2.3.1 Outline
Figure 4 shows an appearance of the detection device which we have developed. This device has A/D and D/A conversion terminals for connection with a personal computer. Those connectors are attached to the back of the device. This device can measure the current of two pantographs at the same time. The measurement signals are inputted into the BNC-input-connectors in the front. If a pantograph-collected current signal is inputted into this device, the device will start the detection of contact loss and output a contact loss judging signal. The contact loss signals are transmitted from the detection device to the personal computer and processed to calculate the contact loss characteristics. The device can also output these contact loss signals and calculated characteristics by the personal computer to the BNC-output-connectors in the front. Thus, it is also possible to monitor the contact loss data directly by a data recorder or by drawing thermal paper charts. It is possible to change the status of this device by carrying out switch operation. This device also contains an input filter for pantograph-collecting current. In addition, if contact loss signals detected by the system of arc light are inputted into this device, this contact loss characteristics will also be calculated simultaneously.

2.3.2 Contact loss judging principle
The contact loss measuring system by AC current is to detect that the current collected by the pantograph becomes zero, when two or more pantographs are connected by an extra high voltage bus on AC current rolling stock. However, because AC current changes as a sine wave, even if contact loss dose not occur, the collected current becomes zero periodically (Hereinafter, we call this “zero crossing”). Then, we adopted the following technique to prevent incorrect detection which processes zero crossing as contact loss. See Figure 5. This is a technique to detect a contact loss when pantograph-collecting current and its differentiation become zero simultaneously. This technique is based on the fact that collected current and its differential don’t become zero simultaneously at the time of no contact loss, because there are a 90-degrees phase difference between them. There is also problem about a threshold level for detecting contact loss in this system. As shown in Figure 6, when the train is powering, the collected current becomes large, and when it is coasting, the collected current becomes small. Then, we designed to make the threshold follow changes of pantograph current rms values. Consequently, we can detect contact loss more accurately because we can eliminate the problems of zero crossing and threshold.
Figure 4: Contact loss detection device by AC current

Pantograph current
Current wave
Full-wave rectified wave
Contact loss signal of pantograph current

Differential current
Differential wave
Full-wave rectified wave
Contact loss signal of differential current
Contact loss signal

Figure 5: Principle of contact loss detection device by AC current

Normal current
Small current
Large current
System mistakes them for contact loss.
System can't detect this contact loss. Threshold

Figure 6: Contact loss detection by fixed threshold
2.4 Contact loss data-processing program

2.4.1 Design of program
The contact loss detection device outputs contact loss judging signals. The contact loss data-processing program calculates them on a personal computer. We designed and completed this software program to have the following functions.

1. This program can process four channels (two channels each for contact loss signals by AC current and arc light) simultaneously.
2. This program can calculate the contact loss rate, contact loss duration time and number of contact loss occurrences on a real time basis.
3. At the time of low-speed run, low-notch, notch-off, stop and passage on a change-over section, this program interrupts calculation.
4. This program can save contact loss characteristics calculated per drum in a hard disk.
5. This program can output calculation results to a contact loss detection device.

In addition, the contact loss rate is the contact loss time divided by the measurement time expressed in percentage. The contact loss duration time is longest one in the drum. The number of contact loss occurrence is the times of the contact loss occurrence.

2.4.2 Contact loss processing picture
Figure 7 shows a CRT picture in contact loss processing. The five panels on the left side display the results of (1) number of contact loss occurrence, (2) contact loss rate, (3) contact loss duration time, (4) main transformer current and (5) running speed, which have been calculated every 0.5 seconds, this program can also display 1,000 past measurements on these panels. In the upper right area, the speed characteristic of the contact loss rate, the contact loss duration time or the number of contact loss occurrence are displayed in a scattering diagram. Buttons (6) perform various setting. If operators want to set up the input-and-output signals, they need to push (7) “input” and (8)”output” buttons. If they want to set up the contact loss detecting condition or the detection start condition, they need to push the button (9).

Figure 7: Display of contact loss calculation program
3 Field test

From some field tests which we carried for Shinkansen by using this system, we obtained good results. Figure 8 shows an example of the measured chart obtained from the field tests. This system can detect contact loss, the contact loss rate, the contact loss duration time, etc. on a real time basis. We can also confirm that the contact loss duration time is long for each overlap. This phenomenon shows a bad condition of overlap composition. Thus, it is possible to easily diagnose the current collecting quality and the states of overhead line equipment from the data. In addition, the contact loss rate and the duration time are displayed somewhat delayed from the time of contact loss occurrence. This system have a time lag against the time of data-processing because it needs 500ms for processing. Since those data are saved in a hard disk, we can reproduce and arrange the data by the data-calculating software after a measurement. Figure 9 shows an example of the contact loss rate and the number of contact loss occurrence for each contact wire drum.

4 Comparison of this system with the former system

To investigate the accuracy of this automatic processing system for contact loss signals, we compared the results of this system with those of the former system about the contact loss rate. Figure 10 shows the results. The vertical axis is the ratio of contact rate of this system to that of the former system. Although there are a few differences, we have confirmed that this system has the same performance to process contact loss as the former system has.

![Figure 8: Contact loss measurement chart in the field test](image-url)
Figure 9: Contact loss rate, number of contact loss occurrence

Figure 10: Comparison of this system with the former system
5 Conclusion

To reduce the work of the contact loss measuring and the data-processing, we have developed a system which can easily be installed for field tests to obtain measurement results on a real time basis. From the results of the field tests, we confirmed the validity of this system. By using this system, we can finish the work to process the contact loss data in a few minutes in contrast to the former system takes about 10 hours.

References