ANS 11th Nuclear Plant Instrumentation, Control and Human-Machine Interface Technologies

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APPLICATION OF HIGHER HARMONICS DIAGNOSTIC METHOD OF ELECTRIC POWER SOURCE FOR RAPID DETECTION OF FAILED ELECTRIC MACHINE IN A REAL NUCLEAR FACILITY BY FIELD WORKERS

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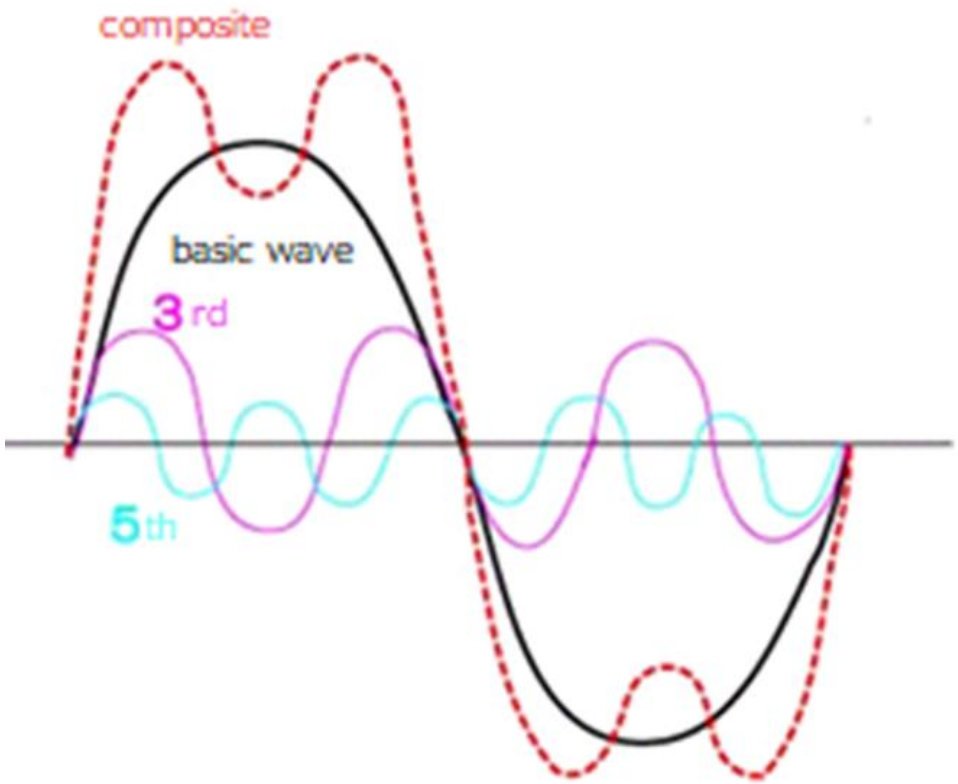
What is higher harmonics diagnostic method?

- The electric current flows through the electric equipment basically as the form of distorted wave which is the composite of basic wave and many higher harmonic waves.



What is higher harmonics diagnostic method?

- If the equipment is working normally, higher harmonic components are not so large in the electric current.
- But when some problem occurs somewhere in parts and modules, specific orders of higher harmonics will appear and exhibit higher percentage in the distorted wave.

- Higher harmonics diagnosis method will diagnose the state of electric equipment by examining what kinds of higher harmonics with their percentage are contained in the distorted wave.

What is higher harmonics diagnostic method?

However, in order to develop a useful diagnosis device with the universal applicability to many types of electrical equipment, it is necessary to collect as many data as possible from many equipment.

As many as 37,200 data of various electric equipment had been collected by the first inventor of this diagnostic device who is called *Hiroshi Koh* for more than ten years from 1991 until 2002.

What is higher harmonics diagnostic method?

By applying principal component analysis method of multivariate analysis for the equipment database, a sort of analyzed table by “contribution ratio table” had been introduced.

“Contribution ratio table” gives the list of the ratios of higher harmonics contained in the distorted wave for the various types of degradation in various parts of various electric device.

How the higher harmonics diagnosis is conducted by using “Contribution ratio table”? It will be explained by an example case in the next three slides.

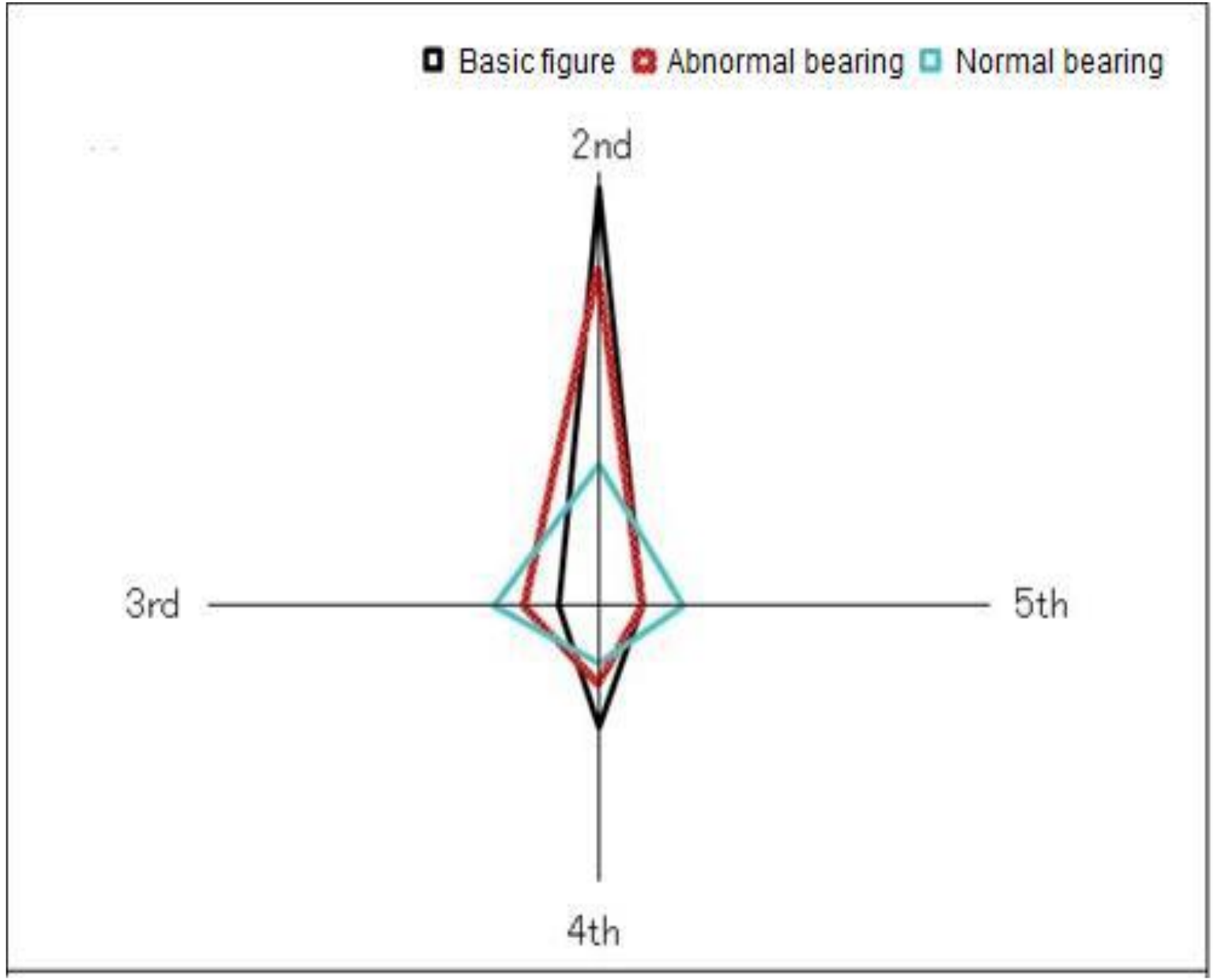
Degradation observed in bearing

Photo 1 Wear of ball bearing

Photo 2 Scratch of bearing case

Comparison of abnormal bearing of the pump with normal one in contribution ratio table

Order of harmonics		2nd	3rd	4th	5th
Contribution index from the measured higher harmonics content ratio (basic figure)		0.944	0.154	0.274	0.103
Normal bearing	Harmonics content ratio (%)	3.1	2.6	1.3	2.1
	Contribution index	0.32	0.269	0.13	0.216
Abnormal bearing (wear of ball bearing)	Harmonics content ratio (%)	2.7	1.4	1.1	4
	Contribution index	0.675	0.35	0.275	0.5


Basic figure
Abnormal bearing
Normal bearing
2nd
3rd
5th
4th

Harmonics Diagnosis and Its Benefit

Contactless and Live State Measurement by search coil at the Control Panel of the local machine.

Enables overall system diagnosis of Abnormality and/or Deterioration for various parts of Motor, Load, and Inverter

-Electric Power Balance is diagnosed to see how the Loading Mode between motor and load. (See next slide)
-Optimum Motor Efficiency to Minimize Motor Loss can be observed.

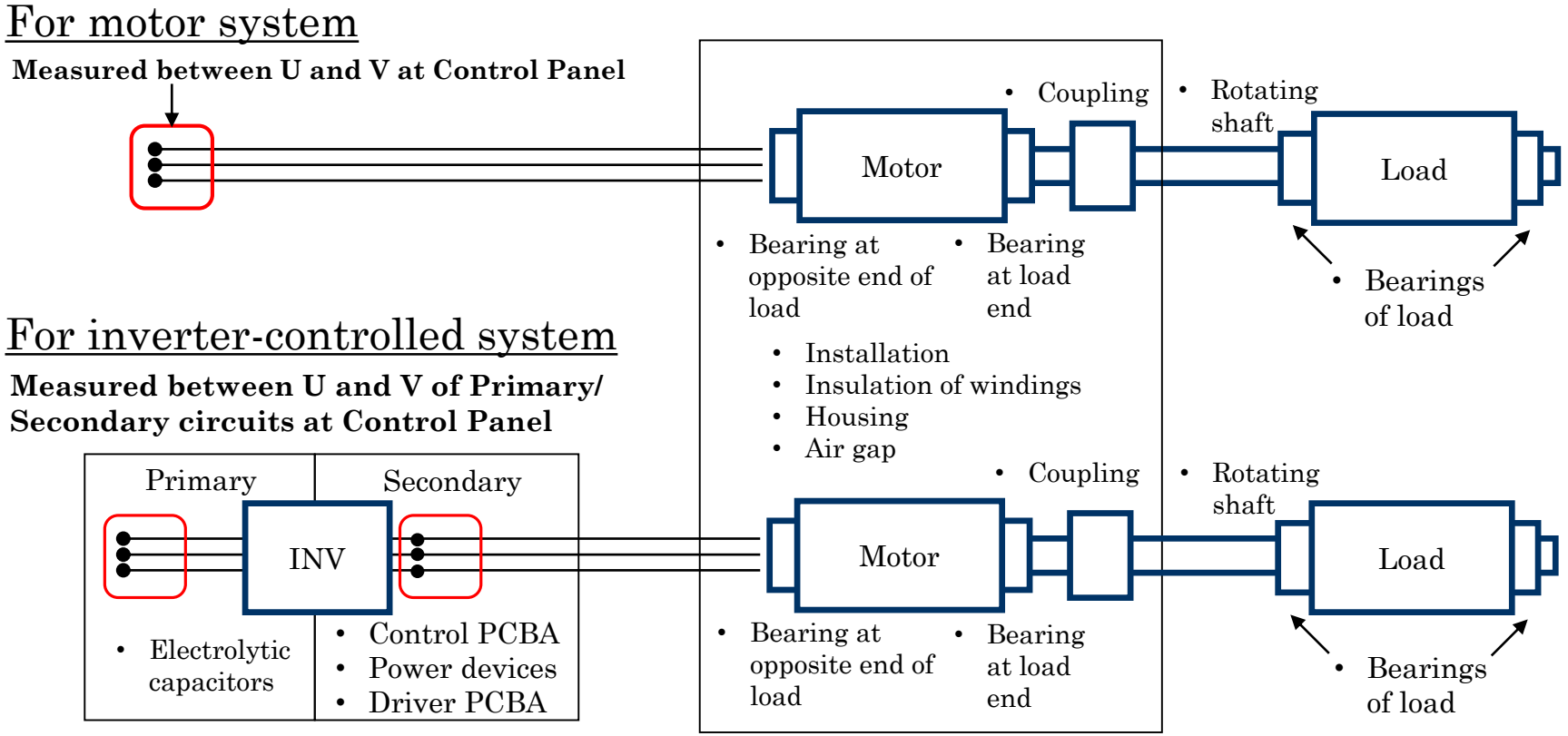
Target of Harmonics Diagnosis

■Diagnosis Target

The primary target of Harmonics Diagnosis is Motor System and Inverter, the driving power source for every industrial moving equipment. In addition, transformer, capacitor, generator, UPS, and power transmission/distribution cable can be diagnosed as well.

■Measurement Location and Diagnosable Part

Harmonics measurement at Control Panel enables diagnosis of the overall system. It is like the blood tests of human body



Realizing diagnostic device for predictive maintenance

HAMOS

KS series

KS-1000・KS-2000

Non-contact type electric equipment diagnostic equipment

KS series is a diagnostic instrument that analyzes, diagnoses, digitizes, and evaluates "harmonic" in the electric current .

This is the sensing technology to grasp and diagnose the state of equipment and to predict abnormality.

【Basic features】

◆Preventive maintenance and predictive maintenance become possible

It can detect symptom of abnormal state, degradation state, and failure prediction.

◆Reduction of maintenance cost

You can measure without requiring any technical skills and so you do not need high technical maintenance personnel.

◆Capable of live line diagnosis

You do not need to stop running the facilities to diagnose. It is also possible to investigate deterioration symptoms (overheating, discharge phenomenon, leakage current etc.) that can only be measured in live state.

【Benefits of introduction】

◆ Equipment plan after introduction It is possible to efficiently collect data useful for prolonged life / update planning in conservation work.

◆ Periodic inspection can be made more efficient. Since it is possible to carry out necessary measures surely within a limited time, the quality of equipment maintenance can be improved.

◆ By collecting data, it is possible to cope with aging of facilities and for environmental change, so that preventive maintenance of machine equipment, extension of equipment life and improvement of performance can be realized systematically.

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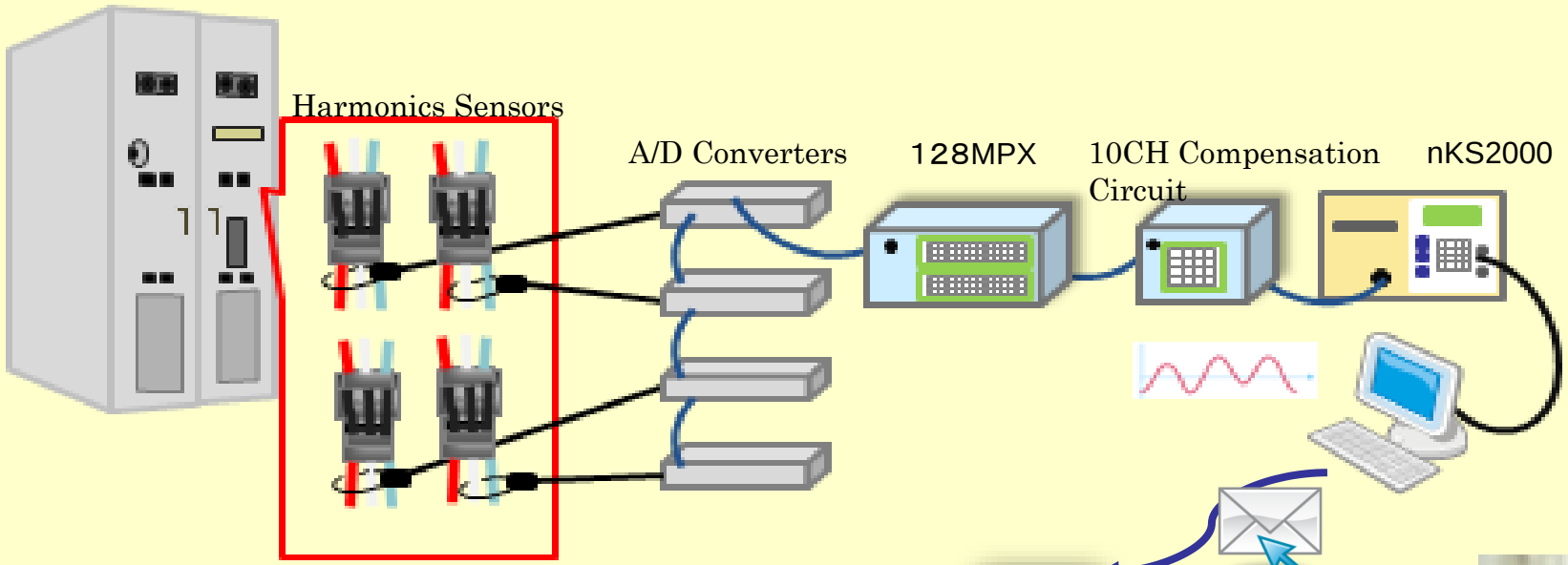
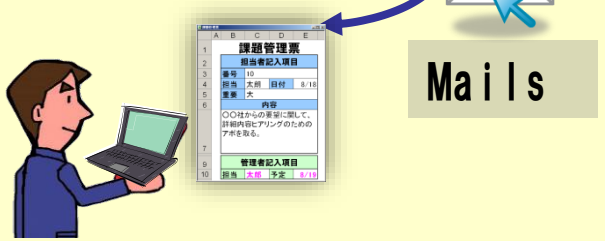
HAMOS System Configuration for continuous remote monitoring

●Harmonics Measurements for Max 1280 Systems Can Be Made



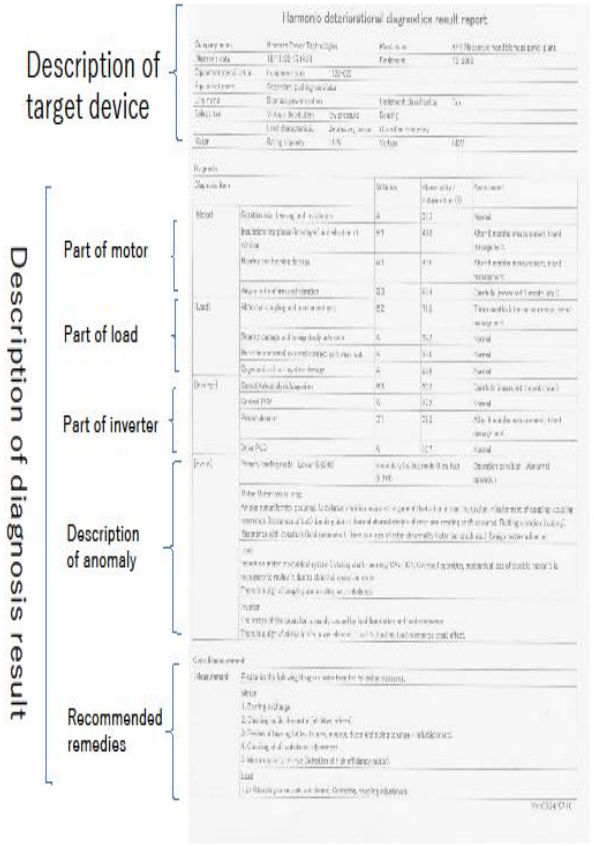


Functions and Features

The Remote MPX can be extended to max 200m long with daisy-chained LAN cables, where one lane consists of 16 channels, and max 8 lanes of the Remote MPXs can be connected. Max 10 units of the Remote MPX can be connected to the Compensation Circuit, and therefore status monitoring of max 1280 channels of systems can be made by the harmonics measurement tool.

How diagnostic result is presented by KS-3000 A

- The results of diagnosing electric device by KS-3000A is presented to the maintenance workers by a sheet of paper.
- The estimated degree of deterioration of the targeted electric device, and both the target device and its attributes as well as the various diagnostic results are described in structured table format as seen from the right sheet.



How diagnostic result is presented

- Various abnormal factors which would deteriorate motor, load and inverter to comprise the target electric device are taken into account in the KS-3000A.
- Based on the estimated abnormality/ deterioration in percentage, the degree of deterioration for individual factors are classified either as A(normal), B1, B2, B3 (light, middle and noticeable deterioration, respectively), or C (worrisome deterioration).
- The advice on how to cope with the problem are also given in accordance with the degree of degradation together with the list of plausible cause of deterioration. Also given is the remedial action to prevent failure.

Where this diagnostic method has been employed

- This diagnostic method has been widely used for automobile companies, rail way companies, electric power companies not only in Japan but also in Korea.
- As for the actual application for nuclear power plant in Japan, it was applied by my advice for three PWR nuclear power stations owned by Kansai Electric Power Company in 2009.
- It was confirmed that all the tested electric devices had exhibited no particular deterioration symptoms. So, all tested devices were like brand new devices, and we at that time thought that this fact would prove the effectiveness of time-based preventive maintenance practice employed in the Japanese nuclear power plants.
- At present, KS-3000A has been employed for diagnosing various electric devices at the Japanese reprocessing plant in Rokkasho-mura, Aomori, Japan.

Concluding remarks

The higher harmonic diagnosis is a diagnostic method of electric equipment based on statistical data analysis method.

It measures the content of higher harmonic in the electric current flowing though the failed equipment, while disassembling the failed equipment to validate the cause of anomaly.

The database of higher harmonics content versus failed part is utilized to reduce a sort of cause-consequence co-relationship between the order pattern of higher harmonic component and the specific cause and parts of degradation in various electric device.

Concluding remarks

Since this diagnostic method depends on experiential data statistics, it has both merit and drawback. The drawback lies in that no theoretical explanation is given on why specific order pattern of higher harmonic appear when a certain failure or degradation occur in a specific part.

The limit of scant database can be overcome by a new wave of big data science by using the present-day Internet of thing (IoT) and cloud computing with artificial intelligent (AI).

This is the new challenge of the presented higher harmonics diagnostic technology, and it is going by the co-author's company which is supported by Ministry of Economy and International Trading (MEXT) as a part of "smart energy system project."

Thank you very much for your kind attention.

Any question and comments?