Introduction

What Is a Power Monitoring Device?

A Power Monitoring Device measures power consumption in order to support energy-saving activities. Electricity is not visible, but it is a familiar, convenient form of energy that is converted into heat, light, sound, power, or other forms and can be used. It is indispensable for our daily lives.

The purpose of environmental protection has been added to the original purpose of energy saving activities to reduce the cost of electricity rates. Moreover, currently it is necessary to produce products while conducting energy saving and environmental protection activities and also enhancing productivity and quality.

Attaining these purposes requires measurement devices that can be used to easily check power consumption and constantly measure it to help save energy.

Types of Power Monitoring Devices

Portable Devices

These Power Monitoring Devices perform checks according to the rated current and circuit type.

Permanent Installed Devices

These Power Monitoring Devices are mounted in facilities and equipment to take measurements.

For details on these products, refer to the KM50 Series Catalog (N167-E1-01) and the KM1 Series Catalog (N170-E1-01).
Power Measurement Mechanism

Measuring Current
One of the methods for measuring the current flowing through wires is to use current transformers (CTs) that apply the principle of transformers. In a current transformer, instead of the transformer primary coil, the wire for which the current is being measured passes through the core. The number of turns in the primary coil operates as a transformer. A current that is inversely proportional to the number of turns in the secondary coil flows through the secondary coil.

\[
I_2 = I_1 / N_2
\]

Differences in Measurement Methods Using Distribution Lines
There are various types of AC distribution line. The number of current transformers and their measurement positions depend on the type.

<table>
<thead>
<tr>
<th>Distribution Line Type</th>
<th>Number of Current Transformers</th>
<th>Measurement Positions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-phase Two-wire System</td>
<td>1 transformer</td>
<td>Primary side</td>
</tr>
<tr>
<td>Single-phase Three-wire</td>
<td>1 transformer</td>
<td>Primary side</td>
</tr>
<tr>
<td>Three-phase Three-wire</td>
<td>3 transformers</td>
<td>Primary side</td>
</tr>
<tr>
<td>Three-phase Four-wire</td>
<td>3 transformers</td>
<td>Primary side</td>
</tr>
</tbody>
</table>

Description of Operations

Basic Operation of a KM50 Smart Power Monitor
The KM50 measures the AC current and voltage, converts these to the power consumption, and outputs the result.

1. Measures the parameters required for calculating the electric power.
2. Performs calculations using the parameters from (1) and converts them into power values.
3. Externally outputs the power values integrated over time (power consumption)
   (a. To display, b. To host device via communications, and c. To alarm output)
**Explanation of Terms**

**Electric Power and Power Consumption**

Electric power expresses the amount of work that electricity can do and it is the amount of work done by electricity in one second. Power (watts) = Voltage (volts) x Current (amperes) W = V x I

The unit is the watt (W).

Power consumption is the amount of energy used, i.e., how much work the electricity did. It is calculated as follows: Power (W) x Time (h). The unit is the watt-hour (Wh).

Examples: 1 kWh = 100 V × 10 A × 1 hour
10 kWh = 100 V × 100 A × 1 hour

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**AC**

AC (alternating current) means that the voltage is changed alternately with time. Frequency expresses how many cycles of the wave are repeated in one second. The unit is the hertz (Hz).

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**Three-phase AC**

Three-phase AC is AC that combines 3 systems of single-phase AC with phases that are 120° different from each other.

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**Transformer**

A transformer increases or decreases the voltage.

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Why AC?

(1) It is simple to produce an electrical generator for AC power.

As shown in the above figure, if you rotate a magnet, electricity is generated (Fleming’s rule).

In the past, water wheels were used. Nowadays, turbines are used.

(2) It is simple to convert an AC voltage.

Long-distance transmission is easy for AC electric power. You can change to the desired voltage by changing the number of turns in the transformer.

Transmitting electricity at higher voltage creates lower loss.

(3) Low-maintenance AC motors can be used.
**Inductive Loads**
An inductive load is a load in which the wires are wound into a coil. Motors are a typical inductive load.

![A coil is approximately equal to an electromagnet.](image)

Characteristics of Inductive Loads
1. An inductive load resists the flow of electricity.
2. The flow of electricity cannot be readily stopped by turning it off.

**Apparent Power**
**Volt-ampere (VA)**
VA is calculated by multiplying the voltage (V) and current (A). Apparent power is the value found by simply multiplying the voltage and the current.

**Active Power**
**Watt (W)**
Active power is power that does actual work and is consumed as energy.
The AC electricity normally used in homes has apparent power (VA) and active power (W). The active power is the apparent power multiplied by the power factor.

**Reactive Power**
**Volt-ampere Reactive (Var)**
This is the power that goes back and forth between the power supply and the load without doing any work.

**Power Factor**
There is active power and reactive power. The power factor is the proportion of active power. This is like the efficiency of electricity usage.

![Lifting a Heavy Load with Two People](image)

The most power is achieved when both people work at the same time, which produces a power factor of 100%.

All together now! If the two people exert themselves at different times, the power is reduced.

**Electric Power**

**Apparent power (VA)**

\[ 	ext{Apparent power (VA)} = \text{Voltage (V)} \times \text{Current (A)} \]

**Active power (W)**

\[ W = \text{Voltage (V)} \times \text{Current (A)} \times \text{Power factor} \]
Further Information

How to Promote Energy-Saving Activities

Why Is Visualization Important?

Centralized Measurement of Power Consumption

**Before Visualization...**

- Air conditioner
- Ventilation fan
- Equipment A
- Equipment B
- Equipment C
- Total: 10,000 kWh

If you only measure the total power consumption, you do not know how much energy is being used where, so it is difficult to take appropriate measures to save energy.

Individual Measurements of Power Consumption

**With Visualization...**

- Air conditioner: 3,000 kWh
- Ventilation fan: 1,000 kWh
- Equipment A: 2,000 kWh
- Equipment B: 1,000 kWh
- Equipment C: 3,000 kWh

This is the same concept as using household account books to ‘visualize’ where to make savings!

Individual measurements enable you to figure out when, where, and how much energy you are using for each application and it makes apparent the points where you can save energy.

The Basics of Improved Energy Saving through Visualization

Key Points for Data Collection

**Visualization Selection**

Implementing Visualization Levels 1, 2, and 3

- Measurement purposes
- Types of data
- Number of measurement points
- Measurement periods

Concept of Extracting Improvement Points

Analyzing from the Perspective of Seven Types of Waste

- Comparison of the actual data against standards

Diagnostics

- Awareness of the amount of equipment required
- Reviewing standards from the perspectives of enhancing quality and productivity, and energy saving
- Imitating successful examples

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**Technical Explanation for Power Monitoring Devices**

- Sensors
- Switches
- Safety Components
- Relays
- Control Components
- Automation Systems
- Motion / Drives
- Power Supplies / In Addition
- Others
- Components
Visualization Levels 1, 2, and 3
Visualization can be divided into three visualization levels according to the power consumption that is visualized and the type of power consumption data that is collected. With the facility shown below, you see what type of power consumption is measured and visualized.

(1) Visualization Level 1: Demand Measurement (Total Consumption)

(2) Visualization Level 2: Secondary Side Measurement (Consumption Breakdown)

(3) Visualization Level 3: Individual Measurement (Energy Balance)
The Seven Types of Waste

Extract margin for improvement from the perspective of seven types of waste.

<table>
<thead>
<tr>
<th>(1) Waiting</th>
<th>(2) Margins</th>
<th>(3) Combinations</th>
<th>(4) Application</th>
<th>(5) Wasted energy</th>
<th>(6) Equipment problems</th>
<th>(7) Old equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wasted energy consumption while waiting and not operating</td>
<td>Waste of energy exceeding the demand and required standards</td>
<td>Waste from equipment combinations and inadequate set values (in parallel or in series)</td>
<td>Waste from application that is wrong for the purpose</td>
<td>Waste from throwing out energy rather than using for a different purpose</td>
<td>Waste from poor energy efficiency due to insufficient maintenance, etc.</td>
<td>Waste from poor energy efficiency due to old equipment</td>
</tr>
</tbody>
</table>

**Example 1** Visualization Improvement Example of Level 2: Margins and Combinations

There is a tendency for factory equipment to be laid out and designed with extra capacity. The key point for eliminating waste is to discover where it is possible for the perspectives of margins and combinations to complement each other and to help stop waste.

**Example 2** Visualization Improvement Example of Level 3: Waiting

Look at certain production equipment, link energy usage and production timing and stop or reduce consumption during times that are not creating added value (i.e., unrelated to production).