Zero Energy High-Sensitivity Camera -Take Clear Pictures of Remote Sites Day and Night with Easy Installation-

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Aging infrastructures such as bridges that are showing signs of deterioration require constant monitoring. Additionally, checks for damages to sites caused by torrential downpours and other natural disasters that have intensified in recent years are also increasing. However, the monitoring faces serious problems regarding cost and labor shortage. OKI currently sells the ZE-GW (Zero Energy Gateway), a series of IoT gateways that does not require power supply or communication wirings and are easy to install (**Photo 1**)[1), 2)]. However, there have been strong requests from the market for a device that enables visual checks of site conditions.

Therefore, OKI has developed the "ZE-GW with High-Sensitivity Camera" that provides remote monitoring (**Photo 2**). The device is able to remotely take clear pictures day and night of aging infrastructures and disaster sites. It is solar powered, so it does not require an external power supply, and there is also no need to lay down communication wirings during installation. It can inexpensively improve the efficiency of inspection work for infrastructure maintenance. This article introduces the "ZE-GW with High-Sensitivity Camera," also refer to as "Zero Energy High-Sensitivity Camera."

Photo 1. ZE-GW Series
(Left: Stand-Alone, Center: With Ultrasonic Water Level Gauge, Right: With Pressure Water Level Gauge)

Photo 2. ZE-GW with High-Sensitivity Camera

Table 1. Zero Energy High-Sensitivity Camera Specifications

Specifications		
ZE-GW Main Unit		Same as stand-alone ZE-GW
Battery Capacity		9 days without sunlight when taking pictures at 30-minute intervals
Camera Specifications	Picture Mode	Still pictures / Automatic high-sensitivity pictures
	Brightness	0.05 lux (pictures possible in light equivalent to moonlight)
	Maximum Pixels	Full HD equivalent (VGA equivalent during standard operation)
	Sensor Linkage	Adjustment of shooting interval according to tilt or abnormal water level
	View Angle	Horizontal: 109 degrees, Vertical: 59 degrees
	Compression Format	JPEG
Dimensions		Main Unit: (W)230 x (D)210 x (H)165mm Camera Unit: (W)146 x (D)180 x (H)229mm

Features and Specifications

Table 1 shows the specifications of the Zero Energy High-Sensitivity Camera.

The device is equipped with OKI's original high-sensitivity camera capable of taking pictures in the dark. It has a small solar panel and battery that enables it to operate consecutively for nine days without sunlight, thus it can continue to operate even if rainy weather is prolonged. Furthermore, the device supports both 920MHz multi-hop wireless "SmartHop®*1)" and 4G wireless communications, and it can be linked with the acceleration, inclination, and natural frequency measurements of structures taken utilizing the existing "ZE-GW with Water Level Meter" and "Wireless Acceleration Sensor." The device can also be linked with OKI's cloud service "Infrastructure Monitoring Solution (monifi®*2)." The system configuration is shown in **Figure 1**.

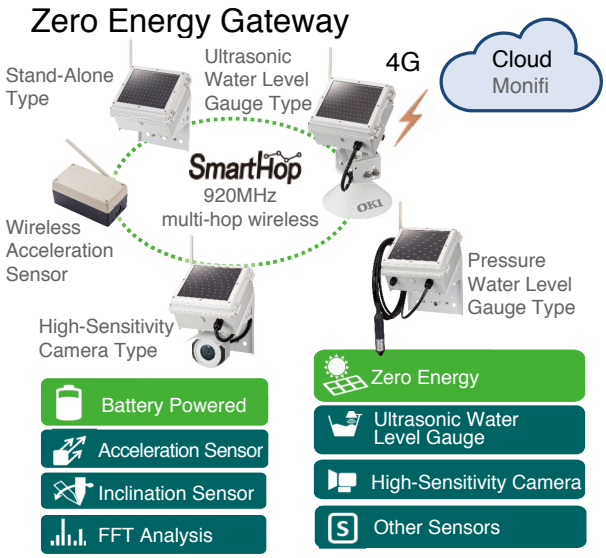

Figure 1. ZE-GW Series Configuration

Technologies

(1) OKI's Original Power-Saving Camera

Figure 2 shows the view of the camera. The newly developed camera is characterized by the high-sensitivity picture shooting, which is possible even in moonlight, and low-power operation using a small solar powered generator. In order to use the camera for outdoor infrastructure monitoring, it must be able to take pictures of the target structure even at night. Therefore, the camera is equipped with an illuminance sensor for shooting control. Using the illuminance sensor to control the shooting parameters, it is possible to take pictures automatically during the day and throughout the night. Additionally, the developing process for the RAW sensor data was designed in conjunction with the infrastructure monitoring application to shorten the calculation time and save power. As a result, the camera is able to take pictures at 30-minute intervals (5-minute intervals in alert mode) and transmit the acquired data to the server via 4G using power generated by a 165mm x 150mm solar panel.

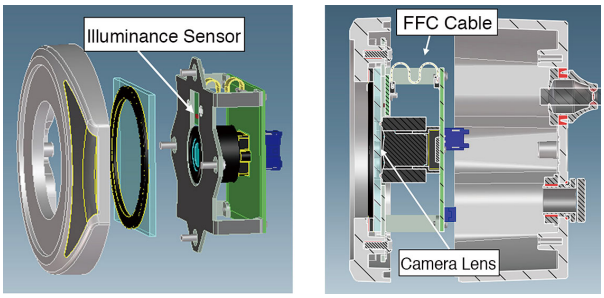

Figure 2. Camera View

The Zero Energy High-Sensitivity Camera has a super-resolution function that is linked with the infrastructure monitoring platform in the cloud. In order to take pictures frequently with low power consumption, the function intentionally transmits low-resolution images to the cloud where super-resolution processing using deep learning is performed to improve picture quality. **Figure 3** shows the effect of super-resolution processing on picture quality. It can be seen that the blurred edges (circled section) in the original low-resolution picture are sharpened and easier to see.

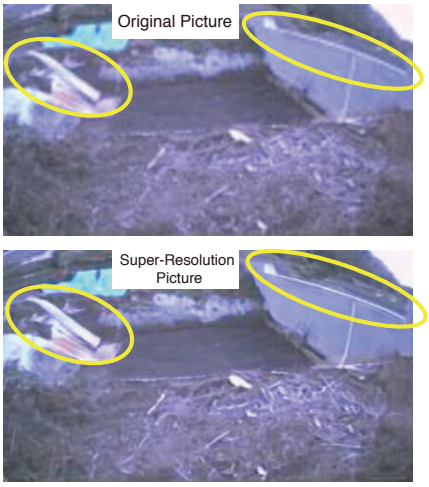

Figure 3. Effect of Super-Resolution Processing on Picture Quality

*1) SmartHop is a registered trademark of Oki Electric Industry Co., Ltd. *2) monifi is a registered trademark of Oki Electric Industry Co., Ltd.

(2) Ruggedized Technology (Environmental Resistance Technology)

Due to its intended use outdoors, special emphasis was placed on the environmental resistance of the Zero Energy High-Sensitivity Camera. The goal was to eliminate condensation and dirt/dust that adhere to the protective glass cover in front of the lens so as not to appear in the pictures and obscure the intended target. Possible measures against condensation are defroster that blows warm air and defogger that heats the glass using embedded heating wire. However, power consumption of the Zero Energy High-Sensitivity Camera must be kept to an absolute minimum, which rules out the use of a defroster or defogger.

Furthermore, since the circuit configuration inside the camera is also designed to minimize power consumption, heat is hardly generated. Therefore, heat usage as a measure against condensation is not a viable option. Instead of using heat, a weather-resistant hydrophilic coating was applied to the glass cover. This prevents condensation from forming water droplets, and there is almost no effect on the pictures. An antistatic function makes dust and dirt in the air difficult to adhere, and even if they do adhere, they wash away with rainfall due to the self-cleaning function. Internally, the glass cover and the camera lens are brought into contact with each other with a rubber camera case, and a narrow airtight space is provided to prevent condensation (**Figure 4**).

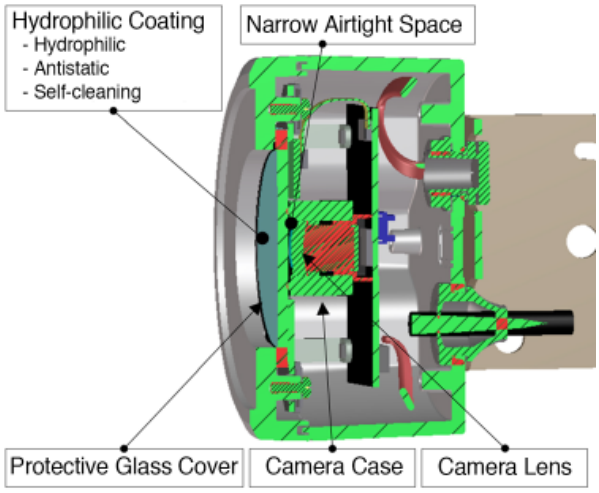

Figure 4. Details of Camera's Front Structure

(3) Sensor Linkage (SmartHop Linkage, Alert Mode Switching)

The Zero Energy High-Sensitivity Camera has an alert mode switching function that links with external sensors such as an acceleration sensor. An acceleration sensor can be connected using 920MHz wireless (SmartHop), and when the inclination of the acceleration sensor exceeds a preset level, an alert notification is sent to the Zero Energy High-Sensitivity Camera via SmartHop. Upon receiving the alert notification, the Zero Energy High-Sensitivity

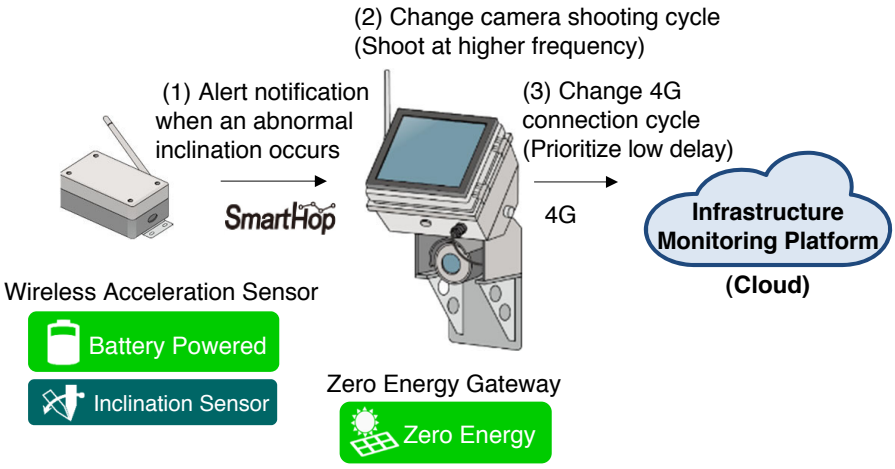

Figure 5. Sensor Linked Communications

Camera switches to a higher shooting cycle so as not to miss changes in the situation at the site. At the same time, the 4G connection cycle, which is normally suppressed to save power, is also increased for more frequent communications with the infrastructure monitoring platform in the cloud. Using these linked functions, the Zero Energy High-Sensitivity Camera is able to operate with low power consumption during normal times and low delay during emergencies while maintaining its small solar panel and device size (**Figure 5**).

Usage Example

The Zero Energy High-Sensitivity Camera is able to take clear pictures of infrastructure/disaster sites day and night then transmit the pictures to the cloud/server. The pictures provide visual confirmation of existing measurements, therefore accurate understanding of the situation and appropriate course of action are possible. Additionally, since the device is easily installable without a power supply or wiring work, it can be used for monitoring existing structures or sites where power supply equipment is not maintained such as reservoirs, rivers and landslide barriers.

As a trial, a Zero Energy High-Sensitivity Camera was installed at a landslide barrier. **Photo 3** shows a picture taken at 2:00am. Despite the time, the situation at the site can be observed clearly.

Photo 3. Landslide Barrier Monitoring (2:00am Image)

Future Developments

The newly developed Zero Energy High-Sensitivity Camera does not require a power supply or wiring work, thus making the device more easily deployable for outdoor infrastructure monitoring. The device adds new value of being able to check site situations visually and opens the door to new applications. OKI is studying two additional functions for the ZE-GW to further expand its areas of application. First function is mixed energy usage. In areas that snow frequently, incorporation of wind power is being studied since the solar panel alone may not generate sufficient power. The second is compatibility with analog sensors such as wind direction/speed, voltage/current, salt damage (electrodes) and distortion (strain) sensors.

References

1) Masanori Nozaki, Kentaro Yanagihara, Kiyoshi Fukui: Demonstration Experiment of Bridge Monitoring System with Wireless Acceleration Sensors, OKI Technical Review, Issue 229, Vol.84 No.1, pp.12-15, May 2017 (in Japanese)
2) Yuki Kubo, Hiroshi Hashizume, Atsushi Yoda: Zero Energy Gateway -Realization of Low Cost Infrastructure Monitoring System with Solar Powered IoT Gateway-, OKI Technical Review, Issue 237, Vol.88 No.1, May 2021 https://www.oki.com/en/otr/2021/n237/pdf/otr-237-R17.pdf

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TIPS【Glossary】

Ruggedized Technology
Technology that adds environmental protection to products and systems such as resistance against heat, cold, water, dust, impact, etc.