

# Wireless Fungal Logger LR8520

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**Abstract**—The Wireless Fungal Logger LR8520 is a data logger that enables objective assessment and management of environmental susceptibility to fungal growth by means of an indicator known as the fungal index. This paper describes the product's features, architecture, and other characteristics.

## I. INTRODUCTION

For warehouses that store products such as grain and documents, museums that house art and historical materials, and similar facilities, preventing fungal growth and halting such growth quickly when it occurs are key priorities.

Some degree of moisture is desirable for operators of grain warehouses since such storage revolves around weight-based transactions, but excess moisture can lead to fungal growth, forcing disposal of entire lots of grain. The Wireless Fungal Logger LR8520 enables personnel to check at a glance whether a given environment is conducive to fungal growth, providing a rough guide for determining how high moisture levels can be allowed to rise.

Operators of document storage warehouses may be required by customers to provide evidence that their facilities are not susceptible to fungal growth. In such cases, the LR8520 can be used to provide this evidence in the form of fungal index readings.

Some building operators use excessive air-conditioning temperature and humidity settings due to concerns about fungal growth, which can occur in locations that are exposed to cool air from air-conditioners. In such cases, the LR8520 can be used to ascertain an acceptable range of settings that are not conducive to fungal growth, avoiding excessive settings and thus helping save energy.

## II. OVERVIEW

The LR8520 can be used to objectively assess and manage environmental susceptibility to fungal growth—a characteristic that until now could only be estimated based on temperature and humidity—by means of an indicator known as the fungal index.

In addition to providing fungal index readings, the instrument can display fungal growth predictions using a five-level, icon-based system derived from cumulative fungal index values. It can also simultaneously record temperature and humidity.

The LR8520 incorporates Bluetooth wireless technology, enabling recorded data to be sent to a tablet or computer that is located remotely from the measurement location and



Appearance of the LR8520.

TABLE I. FUNGAL INDEX GUIDELINES

Fungal index	Amount of time until start of fungal growth	Rough amount of time until fungal contamination
1	2 months	10 or more years
2	1 month	8 years
5	2 weeks	3 years
10	5 days	2 years
20	3 days	1 year
50	1 day	4 months
100	12 hours	2 months
200	6 hours	1 month

making it ideal for performing measurement in inaccessible locations or near room ceilings.

## III. FEATURES

### A. Predicting the Likelihood of Fungal Growth Based on Two Indicators

1) *Fungal index*: The fungal index, which expresses the likelihood of fungal growth as a value from 0 to 200, was proposed by Keiko Abe, Director of the Institute of Environmental Biology, Doctor of Agriculture. If a fungal index of 100 as depicted in TABLE I. persisted, fungal growth would start in about 12 hours, and fungal contamination would start in about 2 months.

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Fungal growth, temperature, and relative humidity are correlated as shown in Fig. 1, and the fungal index can be calculated from the temperature and relative humidity. The LR8520 calculates the fungal index based on the temperature and relative humidity as measured with a high-precision temperature and humidity sensor.

2) *Fungal growth prediction*: A momentary increase in the fungal index does not mean that fungal contamination will start immediately. Because fungus grows only once a suitable environment has persisted for a certain amount of time, fungal contamination can be predicted using the cumulative total of a series of fungal index values. The LR8520 calculates this value as a fungal growth prediction that takes the form of the five progressive icons depicted in Fig. 2.

### B. Alarm Signal Output

The LR8520 provides alarm output that can be connected to an external buzzer or alarm lamp to encourage users to take precautionary action.

Alarm conditions can be set as ranges of values for the fungal index, fungal growth prediction, temperature, and relative humidity.

### C. Power-Saving Function for Long Battery Life

Devices equipped with wireless functionality tend to use batteries quickly due to high power consumption, not only while communicating, but also in standby mode. To avoid this potential pitfall, Hioki equipped the LR8520 with functionality for activating Bluetooth wireless technology only during preset times as defined by a power-saving schedule. Shorter wireless utilization times translate into longer battery life, and battery-powered operating time can approach about 3.5 months when wireless functionality is turned off (with a recording interval of 1 min.; reference value at 23°C [73.4°F]).

The schedule can be set in terms of dates, days of the week, and times.

### D. Data Capture Using a Tablet or Computer

The LR8520 does not require a dedicated device for use in capturing data, which can be downloaded and reviewed on the user's Android tablet, Android smartphone, or Windows computer.

In some temperature and humidity management applications, it is necessary to take measurements near the ceiling. In such cases, the LR8520 frees personnel from the need to use a ladder in order to check measured values near the ceiling by enabling them to collect measured values wirelessly from the ground.

Since the same data capture software is used for Hioki's Wireless Mini Logger series, including the LR8512, it is possible to save electricity by managing air-conditioning

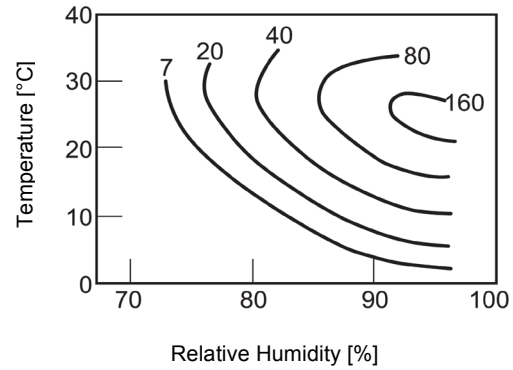


Fig. 1. Fungal index correlation diagram.

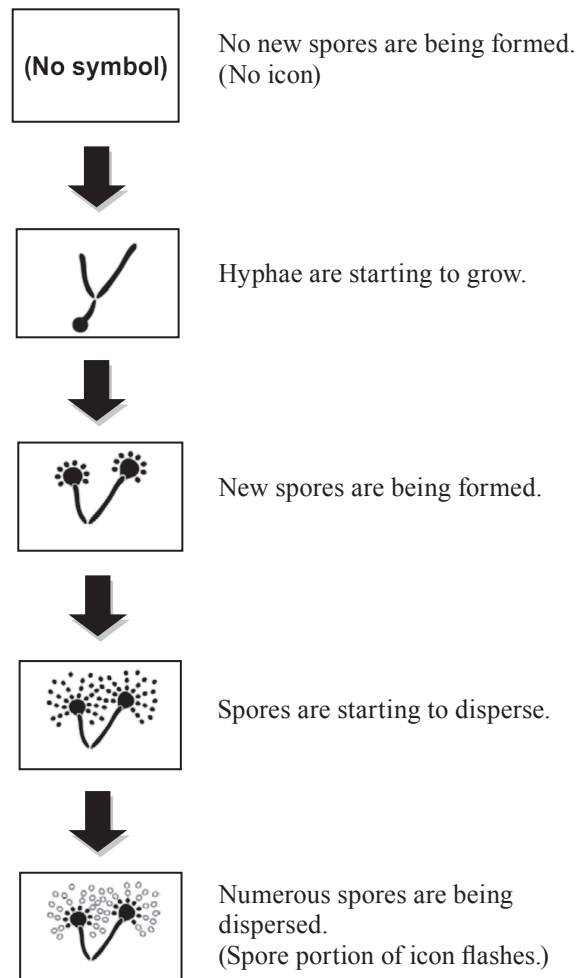


Fig. 2. Fungal growth prediction display.

load current as recorded using the Wireless Clamp Logger LR8513 together with the fungal index.

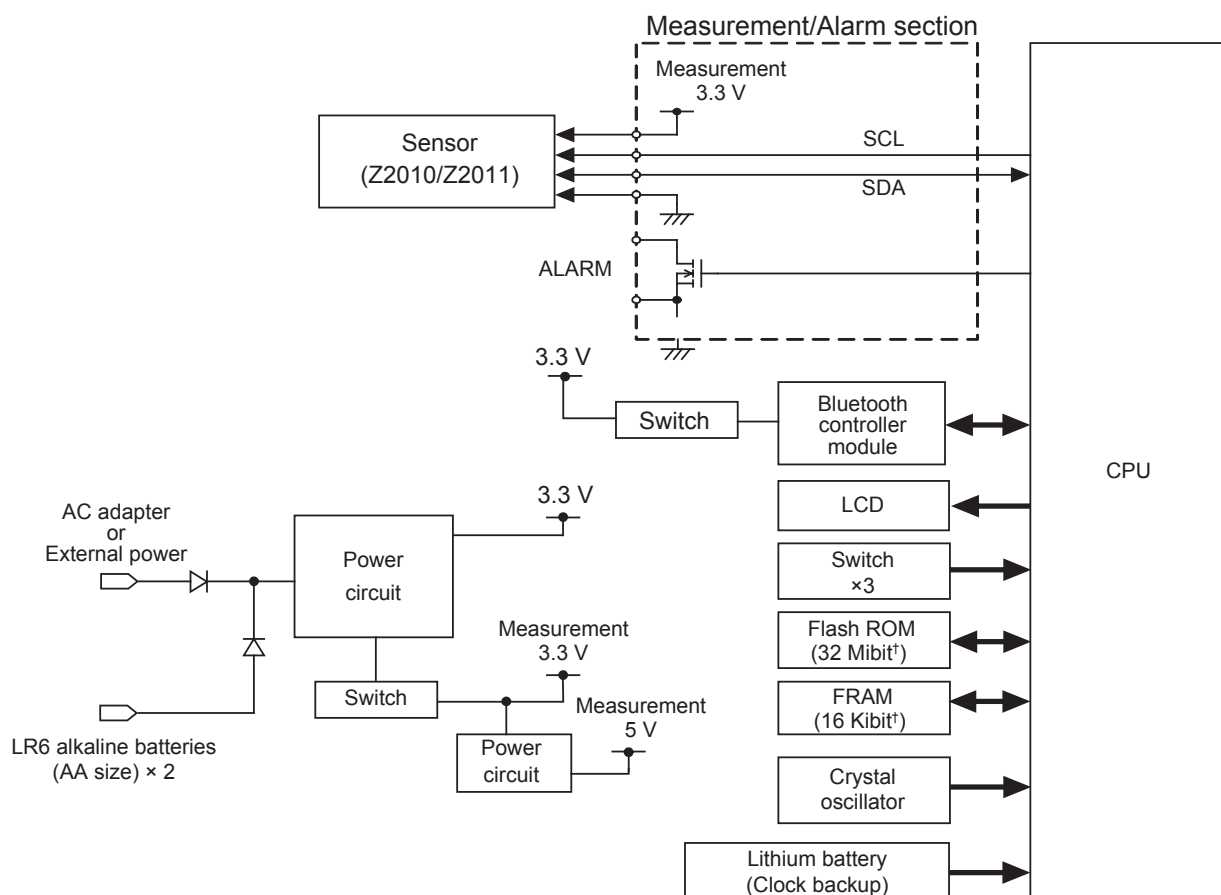


Fig. 3. LR8520 measurement block and overall block diagram.

#### IV. HARDWARE

##### A. Hardware Architecture

Fig. 3 provides a block diagram for the LR8520.

A 16-bit, one-chip microcontroller is used to perform overall circuit control, including such functionality as measurement control, LCD display, key input control, and Bluetooth wireless communications control.

The communications interface uses a Bluetooth wireless communications module, allowing the instrument to communicate directly and wirelessly with PCs and tablets.

Since measurement data is stored in a 32-Mibit<sup>†</sup> flash memory module that serves as the instrument's data memory, it is possible to record data for extended periods of time. Furthermore, data is backed up in the event of a reduction in the battery voltage.

The LR8520 uses a three-way power supply that enables it to operate using an AC adapter, dry-cell batteries, or an external power source, allowing users to choose the power mode that best suits their application. In addition, the instrument is designed to save power by shutting down the measurement power supply while measurement is not being performed and the Bluetooth wireless module when wireless

communication capability is not needed. This design serves to extend the amount of time the instrument can be used while operating on battery power.

##### B. Sensor Architecture

The LR8520 incorporates a high-precision digital-output temperature and humidity sensor that is controlled directly by the microcontroller via I2C communications.

The Z2010 (with a cable length of 50 mm) and Z2011 (with a cable length of 1.5 m) are also available as optional sensors for use in applications that require measurements to be made in corners or on walls.

#### V. SOFTWARE

##### A. Measurement Block

All measurement-related settings are configured using dedicated application software running on a Bluetooth wireless communications-compatible Android tablet, Android smartphone, or Windows computer. The latest

<sup>†</sup> This paper expresses memory capacity in terms of mebibits and kibibits (instead of megabits and kilobits) as required by IEC 60027-2.

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version of all software can be downloaded free of charge from the internet.

Four channels of measurement data are recorded: temperature on the first channel (CH1-T), relative humidity on the second channel (CH1-H), fungal index on the third channel (CH1-F), and fungal growth prediction on the fourth channel (CH1-G).

The LR8520 calculates a fungal index ranging from 0 to 200 internally based on the recorded temperature and relative humidity data, and the resulting value is recorded and displayed. Fig. 1 provides a correlation diagram for fungal index values, which increase as the temperature and relative humidity approach 25°C (77.0°F) and 95%, respectively.

In addition, the instrument calculates a cumulative value for the fungal index and indicates the predicted fungal growth using a five-stage display. Fig. 2 summarizes this fungal growth prediction display.

### B. Alarm

The LR8520's alarm function can be used to illuminate the "ALARM" lamp on the LCD and to control an external device connected to the instrument's alarm output terminal when the fungal index, fungal growth prediction, temperature, or relative humidity satisfies pre-configured alarm conditions.

Four alarm conditions are available:

- If the measured value is greater than the set value
- If the measured value is less than the set value
- If the measured value falls within the range defined by the set upper and lower limit values
- If the measured value falls outside the range defined by the set upper and lower limit values

For example, the following settings would be used to illuminate an external alarm indicator when the fungal index exceeds the value of 30:

CH1-F fungal index

- Judgment method: Level
- Judgment level: 30.0
- High/low: High

## VI. CONCLUSION

If the allowable range of fungal growth is understood, it is possible to save electricity and energy by avoiding excessive air-conditioning settings. We hope that the LR8520 will find use as a measuring instrument that can protect the environment.

Since the launch of the LR8520, new uses that go beyond monitoring conditions to prevent fungal growth have been

proposed by the agricultural sector and other industries, for example by utilizing the instrument to monitor conditions to ensure an environment that is conducive to fungal growth. Going forward, we anticipate conducting more research into new uses for the fungal index.

Shuhei Takeda\*<sup>1</sup>, Shinji Nishimura\*<sup>1</sup>, Chiharu Saito\*<sup>2</sup>

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