

# LED Ceiling Lights featuring Continuous Dimming Control and Color Mixing Functions Contribute to Energy Saving

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## Abstract

To achieve the top level of efficiency in the market of LED (Light-emitting Diode) household ceiling lights, NEC Lighting has developed a stylish LED ceiling light that matches various interiors. Recently developed, this equipment employs LEDs featuring a superior energy saving performance for the light source. It also introduces a technology that illuminates the entire device equally even to the center of the product, a function that was only achieved hitherto by the conventional fluorescent lighting equipment.

## Keywords

lighting equipment, continuous dimming, LED for lighting equipment, directional characteristic constant current circuit, energy saving, color mixing function, current dimming method

## 1. Introduction

Household lighting equipment accounts for 16.1% of the power consumption, which is a rather large percentage and ranks next to that of the air conditioner. As a contribution to power shortage countermeasures, lighting equipment is increasingly identified as a suitable candidate for energy saving measures. In this context NEC Lighting has developed and marketed a ceiling light employing LED as a main light source.

This paper introduces our range of LED ceiling lights featuring continuous dimming control and color mixing functions and also describes product features.

## 2. Features of the LED Ceiling Light

The developed product employs LED as a light source. One of the innovative features of the LED ceiling light is its continuous dimming control function. However, another feature is that it employs two color shades of LED (daylight and incandescent) to achieve the color mixing function (switchable between 3 modes).

Moreover it mounts a multi-angle system that enables uniform luminous intensity distribution performance, which is the essential concept of the product. By combining with a new

power source, it is intended to achieve better luminance and efficiency.

Compared to other manufacturers' products, our newly developed product is equipped with a multi-angle system that has the advantages described below.

### (1) Light distribution technology that illuminates to the center of the product (Multi-angle system)

Since the end of 2011, various manufacturers have started to market ceiling-mounted home lighting equipment. However, most of these products mount decorative panels at the center of the product.

These panels are mounted to compensate the unique characteristics of LED. LED possesses a strong linearity characteristic. Due to this feature, the light cannot be distributed to the center of the equipment so that the central part may be left dark when the LED mounted lighting equipment is switched on. To deal with this issue, decorative panels or sensors are installed in the central part of the equipment with the aim of merging into the product design. However, such a product structure presents difficulties regarding the product design strategy.

The multi-angle system employed by NEC Lighting achieves uniform luminous intensity distribution performance that enables LEDs to distribute light even to the center of the product due to the features described below. The system also allows more freedom for the prod-

uct design that enables it to match various lifestyle scenarios.

**1) LED best match fixing angle with a uniquely shaped reflector**

Instead of lighting a room with the LED's light of linearity from ceiling to floor, our technology enables the luminous intensity distribution to the entire lighting device by reflecting the light from the uniquely shaped reflector that is installed with a fixing angle that achieves highly efficient reflection ( Fig. 1 ). By increasing the angle, the "uneven luminance impression" that is another unique characteristic of LED can be reduced.

**2) Improved reflection rate by installing a reflector coated with a highly reflective material**

To achieve an even more efficient lighting appliance, the surface of the reflector is coated with a paint featuring higher reflection characteristics ( Photo 1 ). This has resulted in an improved luminous intensity distribution

performance to the center of the equipment and also to a reduction of the flux loss due to reflection (a reflection rate of 92% or more was achieved).

**3) Resin coating with light scattering characteristics to improve the uniform light emission performance**

The "uneven luminance impression" cannot be completely cleared even by providing the countermeasures described above 1) and 2), therefore, we employed a resin cover containing superior light scattering characteristics, which improved the uniform luminous intensity distribution performance ( Photo 2 ).

**(2) Appropriate luminance for different room sizes**

High quality and the most appropriate luminance for a room size (numbers of *tatami* mats) can be achieved by changing the number of LEDs thanks to use of the high power and highly efficient type LEDs ( Table and Photo 3 ).

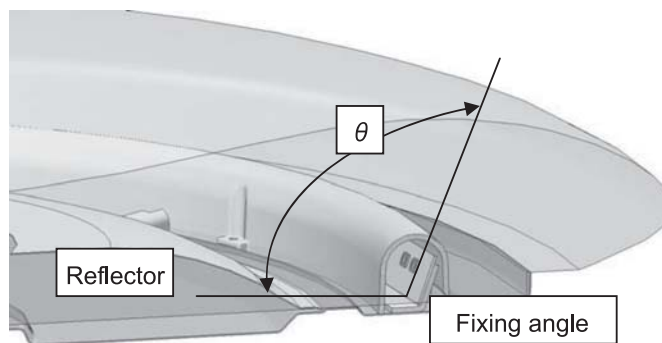


Fig. 1 Cross section of the product.



Photo 2 Light scattering cover.



Photo 1 Reflector.

Table Numbers of LEDs suitable for numbers of tatami mats.

	Daylight color	Incandescent color	Numbers of modules	Total
12 tatami mats	3	2	16	80
8 tatami mats	3	1	16	64
6 tatami mats	1	1	16	32



Photo 3 Modules (daylight color: 3, incandescent color: 2).

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Photo 4 Representative products.

### (3) Long service life

The service life of an LED light source is approximately 40,000 hours, which is almost 2.6 times that of the conventional fluorescent lamp. This enables elimination of lamp replacement that is sometimes bothersome work for users.

### (4) Diversity of design

A wide variety of design developments has been achieved thanks to the multi-angle system that enables adoption of the traditional lampshades and globe-shape covers often used for conventional fluorescent lighting equipment. This has resulted in product development with 21 different designs, which is at the top level of product variation in the global market ( **Photo 4** ). A real wood shade with a Japanese style design is exclusively an NEC product in the market (as of December 2011).

### 3. Remote Controller Capable of Both Operability and Visibility

The remote controller just looks like a smart phone. It employs a stylish form to go with the image of the state-of-the-art LED ceiling light ( **Fig. 2** ). Its tactile qualities when held in the hand and its operability have been improved. An LCD panel and button layout similar to a smart phone allows users to select a desired function with “one-touch” operation.

#### (1) Light timer

Automatic lighting ON/OFF can be set via the time setting on the remote controller.

#### (2) LCD screen

Various settings can be displayed on the LCD screen, such as the present time, timer reservation, present brightness (10 levels) and light-ON mode.

#### (3) Dimming control and color mixing

This device controls the three illumination modes: Active mode (daylight color), Natural mode (daylight white color: Color mixing = Daylight color + Incandescent color) and Relaxation mode (incandescent color). The

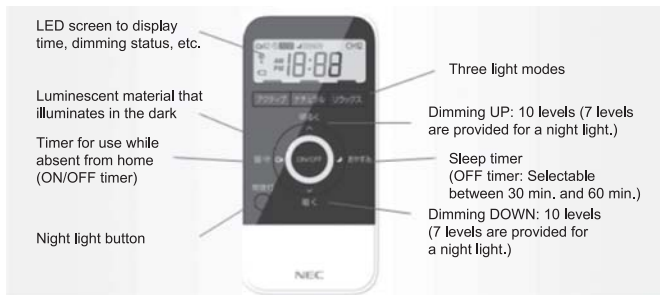


Fig. 2 External appearance of the remote controller and its main functions.

most favorable illumination mode to suit a particular lifestyle scenario can be selected while controlling the dimming function (100% to approx. 10%).

#### (4) Sleep timer

Lighting OFF in 30 min. or 60 min. can be set with a single button operation.

#### (5) LED night light

ON/OFF operation as well as dimming function (7 levels) can be set for a night light equipped with LEDs.

#### (6) Fade ON/Fade OFF

When switching the LED light equipment on and off, it will turn on or off gradually. This function is available with all of the LED lighting equipment except the night light.

#### (7) Demonstration mode

For a lighting demonstration of the lighting equipment display in a shop, a demonstration mode is provided. This mode becomes available by setting a password.

#### (8) Wall switch control

LED brightness can be changed by switching ON and OFF repeatedly at a wall switch.

### 4. LED Lighting Circuits

Input voltage to lighting equipment is 100 V AC in Japan, so control circuits are required to regulate the AC-DC power supply, luminance and lighting mode. The configuration of the power supply unit employed for products introduced in this paper is shown in the block diagram in **Fig. 3** . A microcontroller controls lighting ON/OFF and dimming, and a constant current circuit generates a highly precise and stable output.

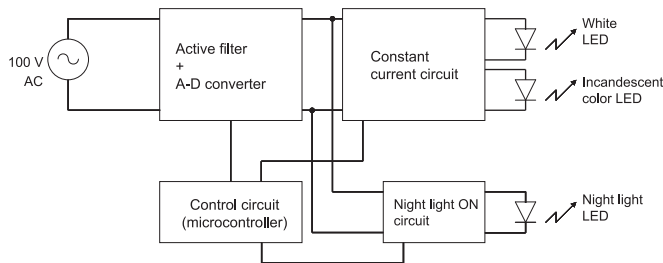


Fig. 3 Block diagram.

The current dimming method is employed for the constant current circuit in order to reduce ripple current so that LED lighting without flicker is achieved. Moreover, a smooth dimming operation is available by controlling the current via a microcontroller so that the current output to the LED varies continuously. When a light is OFF or a night light is ON, the control circuit shuts down the unwanted circuit operations such as an active filter, etc. in order to minimize the stand-by power consumption.

When switching ON the lighting equipment, the continuous dimming function increases the output current gradually so that the light turns on to reach 100% gradually, in approximately 2 sec. When switching OFF, it decreases the output current also gradually from the 100% level of the light-ON status and the light turns off by taking approximately 3 sec. This (fade ON, fade OFF) function creates a luxurious lighting ambiance.

The demonstration mode, described in Section 3, item (7), is programmed so that a demonstration of lighting equipment in a shop can be started by sending a special code from a remote controller. The demonstration mode will not be stopped by switching off the power supply. It is programmed to continue the lighting demonstration until it receives a special code from the remote controller to cancel the demonstration mode (Demonstration function).

By pressing the ON/OFF button repeatedly at the wall switch, the lighting status of the lighting equipment can be changed between full lighting (100%), dimming and night light (Wall switch control function).

Moreover, when the light equipment is turned off by the wall switching operation or a power outage, the last lighting status before being switched off is stored. If a power outage occurs during the light OFF mode, it resumes the last status before the outage (in this case "OFF") so that it can be prevented from being turned ON accidentally when the power supply is resumed.

## 5. Conclusion

Our LED ceiling light with continuous dimming and color mixing functions is a highly value-added household lighting device that achieves energy saving and offers luxurious household ambiance.

NEC Lighting will continue to propose a more pleasant living environment while developing even more advanced products with enhanced usability and appeal to meet the diversified needs of consumers.

In conclusion, we would like to express our gratitude to all those who have assisted in the development of our LED lighting equipment.

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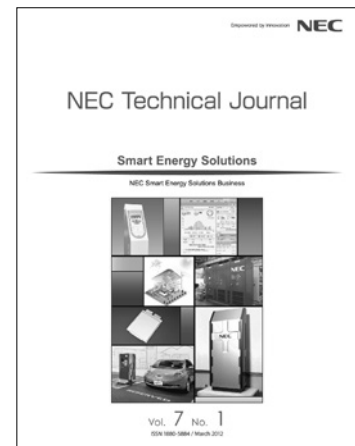
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