

Examination of LED Lighting and Lighting Control System for Night Media Theme Park

You-Suk Kim¹, Eun-Seo Song², Sung-Dae Hong^{*3}

^{1,2}VR Future Center, Seokyeong University, 16-1 Jungneung-Dong Sungbuk-Ku Seoul, 136-704 Korea

^{*3}Dept. of Film and Digital Media, Seokyeong University, 16-1 Jungneung-Dong Sungbuk-Ku Seoul, 136-704 Korea

kimyousuk@gmail.com¹, songsun1999@gmail.com², sungdaehong@gmail.com^{*3}

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Abstract

Background/Objectives: As LEDs are popularized in general lighting, and have been developed from monochromatic light to various light sources, various productions are possible, and are being applied to night theme parks.

Methods/Statistical analysis: We studied the types of LED, how to direct them, and how to control them. We looked at the structure of led lighting, and looked at the basic system and the structure and control method of led which is used a lot recently. In particular, we conducted in-depth research on the control method of driver-integrated leds and also studied the parts connected to control through MCU and various directing programs.

Findings: Through this, the shape of lighting can be made more diversified, and the method of composing the system that can be produced more diversely due to the change of control method was examined. It also studied how to use it in a form that is lighter than the existing led control system and can be linked with other lighting systems. In this study, we examined the communication method used in the existing lighting control system and studied the change of the communication method used recently to find out how to integrate and develop the system. We also studied led module control using SPI communication in the way that mainly use DALI and DMX. Control using SPI communication can be controlled by using MCU, which enables fast and diverse production that the existing simple dimming controller did not have.

Improvements/Applications: It is necessary to actively cope with changes in the system of the dimmer system through the study of leds that are newly changing from the existing led driving methods and control methods.

Keywords: led controller, rgb led module, addressable led control, led directing program, led system, night time theme-park lighting

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I. Introduction

Led is an essential element for the development of high-efficiency luminaires, and

has led to continuous development since its inception. The general household incandescent lamp converts about 10% of the electric energy

into visible light, and the rest is consumed by infrared radiation, but the LED transmits about 90% to visible light, and converts only about 10% to infrared radiation. It is becoming. These leds, however, were difficult to popularize in terms of price, but because they have an excellent lifespan, they quickly occupy the market and are developing in various ranges[1,2,3].

Metal halide lamps[Figure 1] have been mainly used as a light source for creating a forest park at night. Although it is cheap and emits bright light, it has recently been replaced by lighting fixtures using leds, and the public's awareness is increasing because of the variety of possible production. Color rendering, which is a disadvantage of LED lighting, is low, and lifespan change due to temperature has been improved in recent years. If only heat dissipation and stable power are maintained, it is showing a life of more than 30,000 hours[4,5,6].

This paper aims to improve the lighting output of the theme park at night by using the lighting system using the latest leds by studying the shape, components, production system, and control of the LED lights used in the actual theme park.



Figure 1. Metal halide lamps

II. Form of LED lighting

Commonly used led lighting module can be divided into three types. Led lighting modules[Figure 2], which are widely used in media facades, are divided into points, lines, and planes. Point lighting acts as a single pixel and is the most basic form of colorful placement using a point grid system. Each point module is connected by a line, and recent point lights can be controlled by connecting hundreds of thousands. Line modules are often directed with architectural parts. The line module is manufactured by connecting several leds in a line, and expands the direction of production by using the leds which are controlled individually or individually. Third, the plane module has the form of a led panel. The overall controlled plane shape is used in the form of a surface light source, and the individually controlled configuration has a display effect having a resolution depending on the density of the leds.

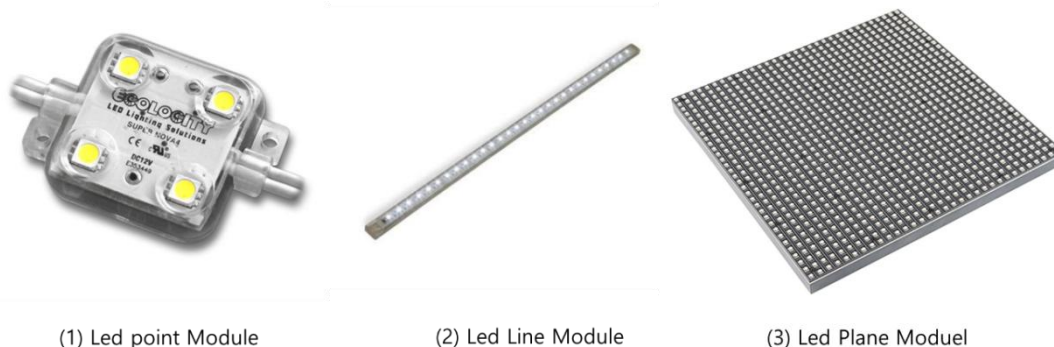


Figure 2. Led Lighting Module

These various types of led modules are also artistically unique. It has a very fast speed compared to conventional lighting, allowing various interactions, and an important feature is lighting, and at the same time can serve as a display. At the same time, it is possible to convey information through graphics and text while creating a space atmosphere. Because of this, there is a difference between the existing

lighting system and the led lighting system in the production and control system. There is an electronic board using a conventional light bulb, but it does not reach the resolution of a much smaller LED panel. Due to the shape and characteristics of these leds, we can both direct and communicate information through lighting in places such as night forest parks. Now let's look at the structure and system of the latest

led.

III. LED System

Each led module has a different control method from the existing lighting system. The basic outline of the existing dimmer system is shown in the [Figure 3].

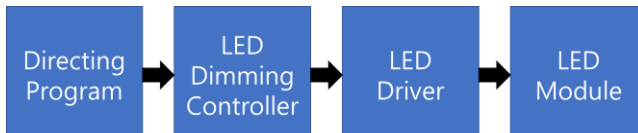


Figure 3. Basic Led System

Conventionally, it is connected to led dimmer controller and various communication protocols through directing program. Each dimmer controller is structured to operate led module by controlling led driver. In the past,

the directing program was controlled by direct control, but recently, the program has been shifted to a computer or MCU. The directing program is described in detail in the next chapter, and the system part focuses on the communication part of the lighting controller. For communication of lighting systems, many standards such as DALI, DMX and RDM have been used. Communication standards that are still in use today, but recently, RGB LEDs, which have a larger amount of data than monochromatic lighting controls, are mainly used. Therefore, faster SPI communication or advanced communication protocols using RS-232 and UDP methods such as DMX512-A and Art-net are used[7,8].

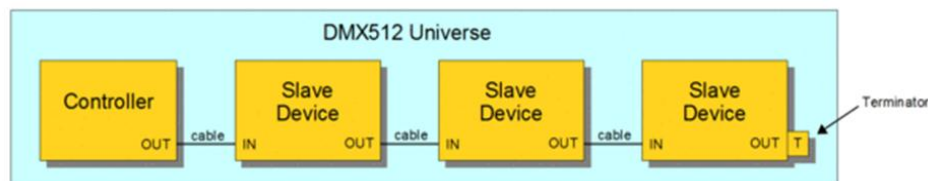


Figure 4. DMX512 System

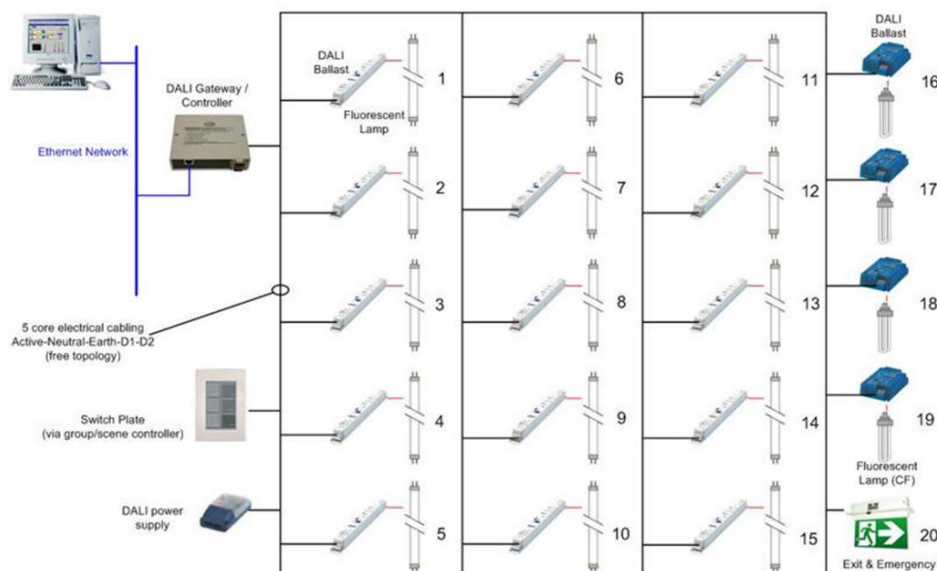


Figure 5. Typical DALI System

Each communication protocol has advantages and disadvantages. DALI has the advantage of being able to communicate a distance of 300m using a 16V voltage and in an easy-to-install way[Figure 5]. However, the communication speed is slow, there is a disadvantage that can

handle only 64 per controller. DMX is a communication protocol that is widely used in lighting systems for performances. One controller can control 512 channels and can be expanded in parallel with a parallel installation[Figure 4]. This change in

communication protocol is coupled with the manufacture of lighting fixtures. DMX and DALI are used as one-way communication protocols, but RDM supports two-way communication. By embedding a more complex controller in the luminaire, you can search for slaves on the master and get back the attribute values of the luminaire. This communication is important in performance luminaires, and is often used in luminaires that require multiple channels, such as moving lights, and are complex to control. Conventional led modules needed drivers and dimmers, but recently, LEDs, which can be controlled only by SMPS and controllers, have

been used. The led chip, called NeoPixel or Ws2812[Figure 6], has a built-in driver in the led chip, which enables RGB color output simply by inputting the power and control communication ports. In this paper, the structure and control method of led represented by ws2812 will be discussed in more depth[9,10]

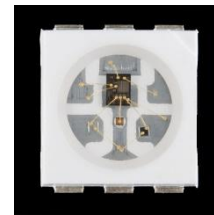


Figure 6.WS2812(NeoPixel)

IV. WS2812 Structure



	Timing WS2812(S)	Timing WS2812B	WS2812D (8mm)	PD9823 (5/8mm)	Cycles
T_{HI_IN} "0"	62.5 ns - 500 ns	62.5 ns - 563 ns	62.5 ns - 600 ns	62.5 ns - 600 ns	<3
T_{HI_IN} "1"	≥ 563 ns	≥ 625 ns	≥ 625 ns	≥ 625 ns	>3
T_{PERIOD_IN}	≥ 875 ns	≥ 1063 ns	≥ 1063 ns	≥ 1000 ns	>5
$T_{DELAY_IN_OUT}$	~ 166 ns	~ 208 ns	~ 208 ns	~ 190 ns	1
T_{HI_OUT} "0"	~ 333 ns	~ 416 ns	~ 408 ns	~ 380 ns	2
T_{HI_OUT} "1"	~ 666 ns	~ 832 ns	~ 812 ns	~ 760 ns	4
T_{RESET}	$> 10.8 \mu s$	$> 9 \mu s$	tbd	$> 14 \mu s$	-

Figure 7.WS2812 Control Timing Speed

WS2812 is a led chip made by China World Semi[11].It is a led module chip with RGBled and driver. Its built-in driver makes it easy to use, and is daisy-chained for automatic addressing and control. It can be easily controlled by MCU like Arduino, and 5V power is used as main power. As shown in [Figure 7], it has very fast control speed and is manufactured and used in various forms. In the lighting industry, it is used for landscape lighting, tree lighting, and sign display, and is mainly used in media facades. With the popularization of MCUs like Arduino, NeoPixel is being used by companies like Adafruit, a New York-based company. It is an important part in lighting production of forest park, and it is a led module that enables simple

and diverse production. It has the features that can form all the forms such as point, line, and surface discussed above.

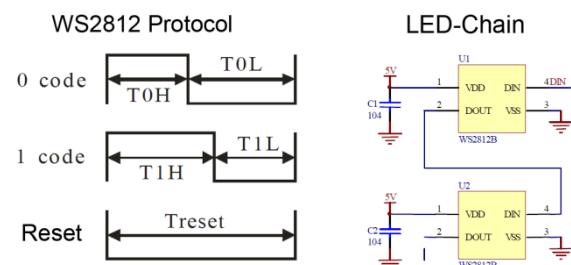
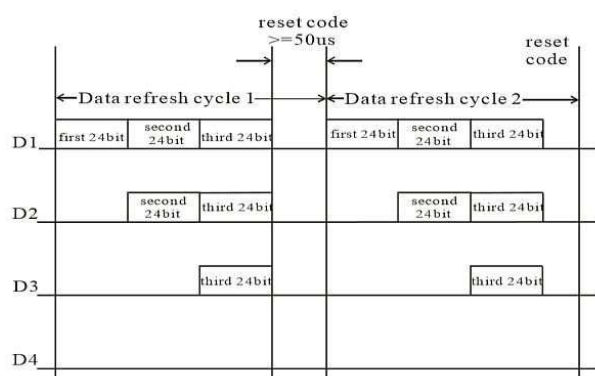


Figure 8.WS2812 Protocol & Chain Circuit

The protocol of the WS2812 is controlled by the application time of a voltage representing 0,1. It works by controlling GPIO from MCU and signaling to DIN of WS2812 and applying 5V through SMPS. In a general digital circuit,

1 means power is applied and 0 means power is not supplied. However, the protocol is to deliver a more complex content by generating a promise rule based on a difference between two power-up times. The protocol of the WS2812 is a promise between the led module chip and the MCU. The WS2812 is a variant of communication based on SPI communication. In [Figure 8], the LED chain shows a circuit that is daisy-chained with addresses. In the daisy chain method, if the led module chip connected first is 0, then the chip connected to Din through Dout is automatically assigned to number 1. It is easy and simpler than DMX channel configuration because it is addressed through simple wiring, and it is very convenient for mass led control. In the case of DMX, manual channel setup takes a long time in the initial installation environment.



Data transmission method:

Note: The data of D1 is sent by MCU, and D2, D3, D4 through IC internal reshaping amplification to transmit.

Composition of 24bit data:

R7	R6	R5	R4	R3	R2	R1	R0	G7	G6	G5	G4	G3	G2	G1	G0	B7	B6	B5	B4	B3	B2	B1	B0
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Note: Follow the order of RGB to send data and the high bit sent at first.

Figure 9. WS2812 Data Structure

In the WS2812 data communication method, as shown in [Figure 9], 24-bit led color information data is transmitted at 50us. A total

of three 24-bit data are transmitted at a time, and the data is transmitted to the led of the next address through the latch system built in each led module. Latching systems, such as analog switches, maintain their old values until new data is entered. This allows each module to continue sending data to the next chip. One module chip control is allocated 8 bits each for R, G, and B and controlled in 256 steps, which can theoretically express a total of 16777216 colors. Very delicate expressions are difficult, but more diverse expressions are possible in the direction of increasing resolution through various arrangements.

V. Directing System

The production system using WS2812 can be divided into stand-alone structure and remote structure. Stand-Alone structure uses various MCU, but it converts simulated graphic to data through computer and saves it to SD card. Once stored, the value is activated when the entire system is powered up. The led simulation program can use built-in effects or create your own. Figure 10 shows the LedEdit[12] program and drive controller K-1000C, which are often used for commercial purposes. Input Led circuit and arrangement by LedEdit with CAD method first, add graphic on it, and save LED information value of the relevant part, save it to SD card and insert it into drive controller. It is extremely fast and convenient to use, and a stable system when no special communication is required. In recent years, the German Madrix system[13] is also frequently used, but at a high price, it is difficult to use in general.

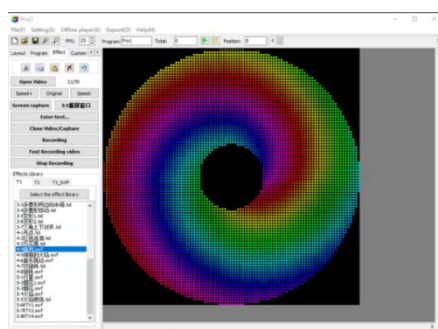


Figure 10. LedEdit Software and K-1000C Led Controller

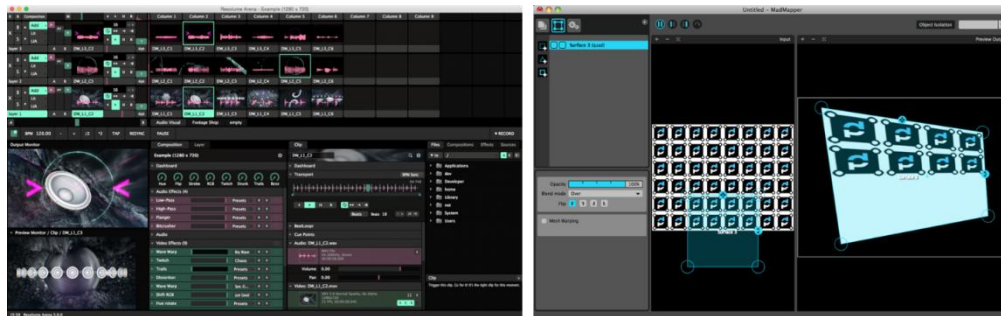


Figure 11. Resolume and MadMapper

Secondly, the computer-based remote method is a video mapping method using a VJ tool which is frequently used in media facades and performances. VJ software supports communication protocols such as DMX, Midi, and Osc. This is a method of controlling the led by converting the communication protocol. Because it can be controlled in real time, it provides interactive lighting control and lighting according to the situation. Resolume[14] and MadMapper[15] are mainly used in the representative VJ software [Figure 11]. Resolume is a software that focuses more on mapping, if the main purpose is to select and play back images like a multichannel video

and DJ. MadMapper is used more for led control, and Resolume is mainly used for high-capacity graphics such as Led Panel. In addition, direct control method through programming of MCU. Coding can also be done when interactive work is required or when very fast production is required. Control with AdaFruits's NeoPixel library[16] is typically easy to produce with Arduino, while PJRC's Teensy board [Figure 12] uses the Arm core and can control a much larger number of ws2812s than Arduino[17]. In addition, the Linux-based Raspberry Pi can be used for coding in various programming language-based environments such as Python and C++.

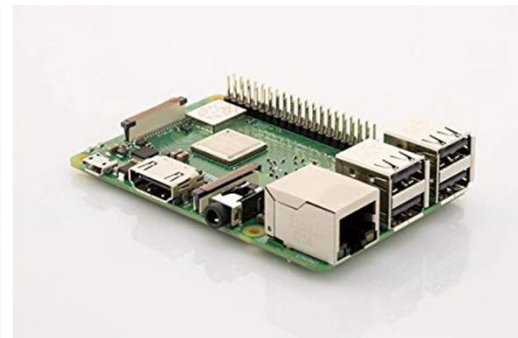
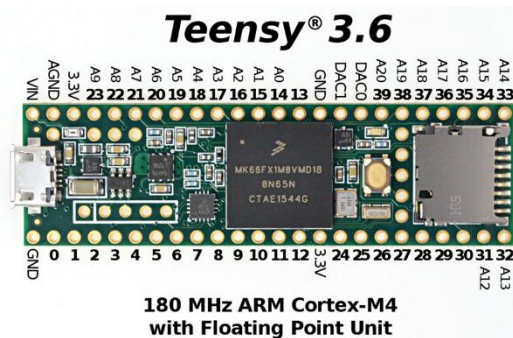


Figure 12. Teensy 3.6 and Raspberry Pi

VI. Conclusion

The various types of LEDs for applying to the park theme park were examined, and the structure, control method, and direction software for utilizing ws2812 were studied. The existing lighting market was somewhat closed, but is rapidly changing due to the development and popularization of Led modules and MCUs. We explored lighting protocols and recently used software in more depth than general usage environment.

Through this, it will be possible to make indoor and outdoor lighting production more cheaply and effectively, and if developed, create an atmosphere of theme park that impresses people with colorful and delicate expression of light.

VII. Acknowledgment

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