

# Development of Wireless Dimming Control System for LED Stage Light

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**Abstract** .Compared with the existing wire dimming system of LED stage light which uses the heavy light operating console to adjust the brightness of stage light, a portable wireless dimming control system for LED stage lighting is proposed, fabricated and tested in this paper. The scheme with the core of ATmega16L microcontroller is composed of wireless transmission and reception units, constant current driving circuit of LED, and the control circuit between this two modules. Through the system presented here the dimming signals are transmitted from transmission unit to reception unit, and the brightness of the LED stage light varies consequently. The experiment results show the feasibility and convenience of the proposed wireless LED dimming system for LED stage light.

## 1 Introduction

As a new generation of environmental light source, LED has been widely used in many areas because of high efficiency, low driving voltage, low power consumption, long life and other characteristics; a variety of colored lights based on the LED is used everywhere. It becomes possible applications to replace the incandescent bulb and fluorescent lamp in residential, industrial as well as commercial performance, stage lighting. As to LED stage light, the brightness of it should be varied as different scenes. So the dimming system for LED stage light is indispensable<sup>[1]</sup>.

The common dimming system consists of light operating console, dimming controller and other auxiliary components. The dimming signal is transferred through communication lines between components. This system not only has the complex construction and bad flexibility, but also influences the application in outdoor performance. For this reason a portable wireless dimming control system with a dimming handle to take place of the heavy operating console is put forward in this paper. The dimming system is made up of wireless transmit unit, receive unit, and constant current driving circuit of LED. These two units communicate through nRF2401 wireless RF module so as to realize short distance brightness transformation of LED stage lights.

## 2 Overall design of system

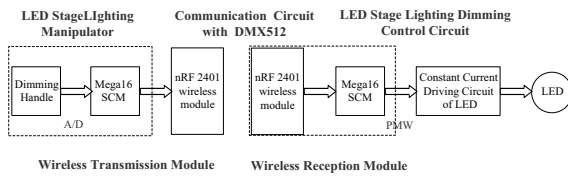
The structure diagram of dimming control system for stage light is shown in Figure.1. The dimming system is mainly composed of a wireless transmission unit, a wireless reception unit, and the constant current driving circuit of LED. As to the transmission unit, it includes a

LED manipulator and a wireless RF module. Compared with the traditional dimming system, the LED manipulator proposed here use a dimming handle instead of the heavy operating console to improve the portability of the system. With pulling the dimming handle, the output voltage of the handle is changing consequently, moreover, the voltage is converted into a 10- bits digital signal by the analog / digital convert unit of single-chip microcomputer (SCM). Subsequently, the digital signal is packaged according to the DMX512 data transmission protocol and sent to the SCM's output port. Through the part of LED manipulator the signal converts for analog into data segment meeting DMX512 protocol format<sup>[2]</sup>. Then the data is sent to the reception module through NRF24L01 wireless communication module .As far as the reception unit is concerned, it involves a wireless RF module and ATmega16L microcontroller. This unit along with the constant current driving circuit constitute the LED stage lighting dimming control circuit. According to the circuit, after collecting the dimming signal transmitted by RF module, the SCM of the dimming circuit generates a Pulse-Width Modulation (PWM) control signal to drive constant current source circuit according to the dimming signal received. Finally, the constant current driving system dims the LED lights based on the PWM signal. Because the luminance is mainly affected by LED driving current, so the selection of LED driving mode will directly influence the effect of light dimming. In a word, the LED stage light can be dimmed wirelessly in a short distance by the system proposed here<sup>[3]</sup>.

## 3 System hardware design

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### 3.1 Wireless transmission unit



**Figure 1.** Diagram of wireless dimming control system

Wireless transmission unit is made up of dimming handle, ATmega16 SCM, nRF2401 wireless RF module. The SCM processes the dimming signal generated by the dimming handle and then sends the signal to the receiving part through nRF2401 wireless RF module.

#### 3.1.1 Dimming handle

The dimming handle is essentially a continuously variable potentiometer, which is used to adjust the dimming signal so as to change the brightness of the LED stage light. With turning the knob of this element, its output voltage alters simultaneously, it subsequently is sent to the port PA0 of the SCM.

#### 3.1.2 Micro control unit (MCU)

MCU should convert the signal gathered through PA0 into a 10- bits digital signal ,and packaged it according to the DMX512 data transmission protocol, i.e. data segment meeting DMX512 protocol format. Additional, the transmission unit employs nRF2401 for wireless communications, MCU should also has a SPI interface. Integrating above needs as well as the demands of low cost and low power, ATmega16L is selected as the MCU. ATmega16L made by ATMEL is a high performance, low power consumption of 8 bit CMOS microprocessor. it is also provided with rich resources on chip: 16K bytes of programmable Flash in system, 32 general I/O lines, three PWM output interfaces, programmable serial USART, 8 10-bit ADC, a SPI serial port.

#### 3.1.3 nRF2401 wireless RF module

nRF2401 is an industrial-level wireless transceiver with built-in hardware link layer protocol<sup>[4]</sup>. The device works within 2.4 GHz ISM band, internally installed frequency synthesizer, power amplifier, crystal oscillator, and modulator, also fused with enhanced ShockBurst technology, its output power and communication channels could be configured by the program. Additional, it possesses two data transmission mode and the built-in SPI interface; so, MCU could control it through the SPI interface. The nRF2401 module used in transmission unit is controlled through port PB.

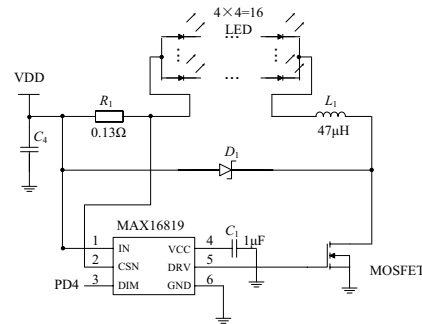
### 3.2 Wireless reception unit

Wireless reception unit is composed of nRF2401 wireless RF module, ATmega16 SCM. The DMX512 data received by nRF2401 from transmitting module is

processed by the microcontroller to produce PWM signal; PWM signal is output through port PD4 to control the driving circuit so as to realize the effect of brightness changing.

### 3.3 Constant current driving circuit of LED

According to the electrical characteristic of high-power LED array, there are two major driving methods, constant voltage driving method and constant current driving method. Most of the high power LED drivers nowadays, adopt constant current driving mode. As to choice of the high power LED stage light designed here, we use the constant current drive method. Fig.2. shows the proposed constant current driving circuit.



**Figure 2.** The constant current driving circuit on chip MAX16819

The high-power LED stage light constant current drive circuit designed here is basically constructed by one current detection resistor  $R_1$ , one inductor  $L_1$ , two capacitors  $C_1$  and  $C_4$ , one MOSFET, one freewheeling diode  $D_1$  which can provides a continuing loop for the current flowing through the inductor  $L_1$  during the MOSFET closes, and step-down constant-current high-brightness LED (HB LED) driver --MAX16819. The chip is a buck converter. It operates from a 4.5V to 28V input voltage range and features a 5V/10mA on-board regulator. The output current is regulated by high side current sensing resistor  $R_1$ , adjustable pulse brightness achieve wide range. The hysteretic on-time controller and an external resistor allow the converter output voltage to adjust as needed to deliver a constant current to a series-parallel connected LED arrays. This chip used here to provide an adjustable constant forward current four strings of four series connected 5W LEDs<sup>[5]</sup>.

The PWM signal output through the PD4 port of the SCM is sent into DIM. A logic level below 0.6V at DIM forces DRV output low, turning off the external MOSFET. When the logic level at DIM is more than 2.8V, the MOSFET turns on. With the MOSFET being on, the freewheeling diode--  $D_1$  cuts off, VDD began to power supply the inductor  $L_1$ , the high current ripples to the peak value linearly in the loop of VDD-  $R_1$ -LEDs-  $L_1$ -MOSFET-GND. When the MOSFET is off,  $D_1$  turns on, providing a continuous path for the inductor current, then the high current circulates through  $R_1$ -LEDs-  $L_1$ -  $D_1$ . Its value ripples down for the peak value. The dedicated PWM input DIM enables a wide range of pulsed dimming which is available for the need of the brightness variety for high-power LED stage light.

## 4 System software design

Software design of the system includes the program design of wireless transmission unit and program design of wireless reception unit, and DMX512 data package. The design of transmission unit program includes the dimming signal processing and nRF24L01 wireless communication program, the design of reception unit program mainly involves the data receiving, data processing and the output of PWM signal.

### 4.1 Program design of transmission unit

After the transmitting unit starts, firstly it will complete initialization of the system, including the I/O port initialization and nRF2401 initialization. Then the analog dimming voltage is acquired and processed to the data segment meeting DMX512 protocol format. This data segment is transmitted through to reception unit. If the reception unit doesn't receive the data in a certain while, the segment will be sent repeatedly until receive the reply of receiver. Its flow chart is shown in Figure.3.

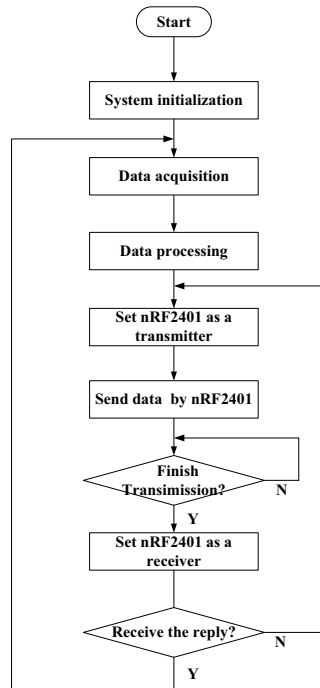


Figure 3. The program flow chart of wireless transmission unit

### 4.2 Program design of reception unit

After the Reception unit starts, firstly it will complete initialization of the system too. The main function need the reception unit to realize is to use PWM technology to control the brightness of LED stage light after the data information received from the transmitting unit is processed, its flow chart is shown in Figure 4.

### 4.3 DMX-512 protocol

DMX512 Protocol specified by the Technology Association of America Theater in 1987, it is an entertainment industry standard based on RS485, which

is mainly used to control stage lighting. It covers electrical characteristics (based on EIA/TIA-485 standard), data format, data protocol, and connector type. Meanwhile, it is an Asynchronous Serial Digital Data Transmission Standard for controlling lighting equipments and accessories [6].

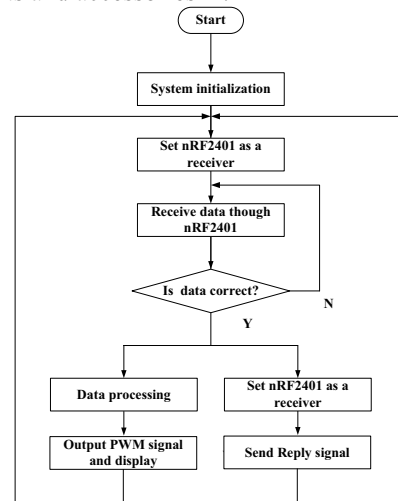


Figure 4. The program flow chart of wireless reception unit

DMX512 controller transmits data package to dim the stage lighting. The data transmitted shall be in asynchronous serial format and must meet the format and the timing of DMX512 protocol. That is fixed at one start bit, eight data bits, two stop bits and no parity. Prior to the first level transmitted, a RESET signal shall be transmitted followed by a NULL START code. Valid dimmer levels shall be to 255 decimal (00 to FF hexadecimal) representing dimmer control input levels of OFF to FULL in a linear relationship. Fig.5 shows the timing diagram of the data package in detail [7].

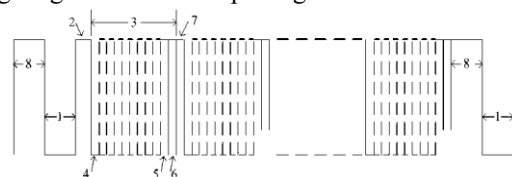


Figure 5. Timing diagram of the data package

## 5 Experiment and results

After the wireless dimming control system is set up, it could be debugged and the operating results also could be observed, the actual operating results are shown in Fig.6. When the dimming handle slide from turn off to fully open, the dimming signal of Transmission unit alters from 00(H) to FF (H), and the signal of reception unit changes equally.

Output the dimming signal to the constant current driving circuit, the brightness of the LED stage light will vary with the signal. Fig .7 illustrates the dimming effect of the dimming control system for LED stage light.

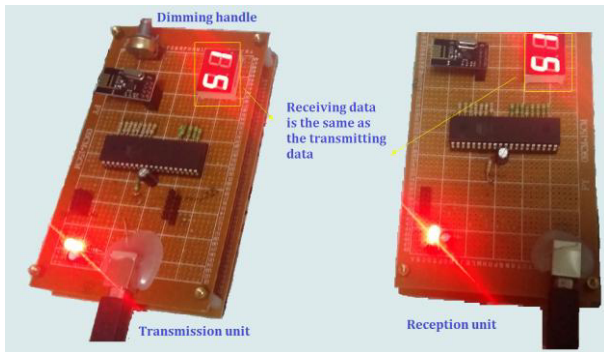


Figure.6 The actual operating results of the wireless dimming system

## 6 Conclusion

In this paper, we present a wireless dimming control system for LED stage light, which can realize short distance brightness transformation of LED stage lights through wireless communication module nRF2401. The experiment results show the feasibility and convenience of the proposed wireless LED dimming system for LED stage light.

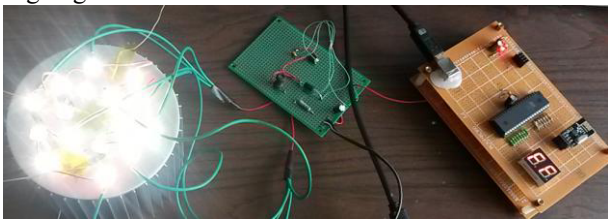


Figure .7 The dimming results of the wireless control system for LED stage light

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