

### General Description

This user manual describes the functionality and characteristics of the AL58221 RGB LED driver using demo board, which is an alike SPI bus controlled, 12 channel, constant current LED driver. This user manual includes hardware and software setup instructions, schematic diagram, bill of materials, printed-circuit board layout drawings and demo board images.

This demo board characterizes the features of AL58221 RGB LED driver. The main goal is to exercise clear and bright LED effects by communicating through MCU. This demo board has an additional feature of providing supply to the LEDs using power bank connected through USB Type-C connector or AAA battery.

### Key Features

- Input Voltage VDD: 3V to 5.5V
- Constant Current Output Range
  - 3~60mA@5V
  - 3~35mA@3.3V
- 12 Constant-Current Sink (R/G/B x 4) Output Channels
  - RGB Output Current setting by 3 external resistors
  - 24V Rated output channels for long LED strings
  - ±1% (typ.) LED Current accuracy between channels
  - ±2% (typ.) LED Current accuracy between devices
  - 16 / 14 / 12 / 8 bit grayscale selection
  - Grayscale clock source selection: internal or external
  - PWM or APDM control selection
  - Programmable Output Current Trise / Tfall time
  - Output Current Bilateral Processing for EMI reduction
- Diagnosis and Protections
  - Built-in internal grayscale clock supports refresh rate >1000Hz@16-bit grayscale, >256KHz@8-bit grayscale
  - Internal Grayscale clock frequency selection for High Power LED driving application (min. 33.6KHz)
- 2-Wire Serial Interface (DI, DCKI)
  - 20Mbps (max.) ~ 140 Kbps(min.) data rate for EMI reduction data transfer
  - Cascaded capability (Max 1,030 devices)
  - Clock duty recovery for cascading application
  - Schmitt trigger input

### Applications

- Indoor and Outdoor LED Video Displays
- Architectural and Decorative Lighting
- Digital Signage and Billboard Applications
- LCD Display Backlighting
- Transportation Sign

### Specifications

Parameter	Value
Input Voltage	USB-C / AAA batteries
Output Current	40mA
Output Voltage	5V
Dimension	165mm*80mm*25mm
RoHS Compliance	Yes

### Evaluation Board

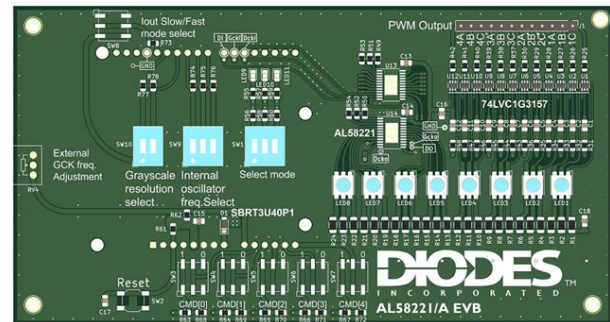


Figure 1: Top View

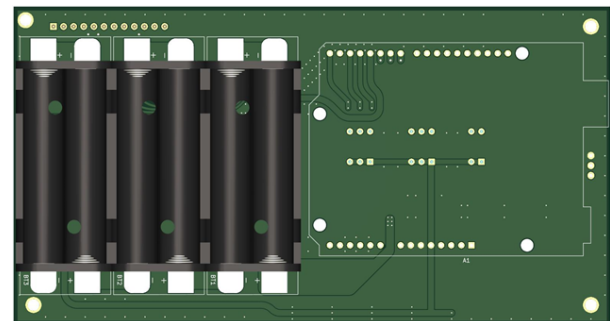


Figure 2: Button View

### Connection Instructions:

- DC Input: USB-C / AAA dry batteries

## Description:

The demo board consists of the following major components.

### 1. AL58221\_12-channels (R/G/B x 4) constant current APDM

The AL58221 is a 12-channels (R/G/B x 4) constant current APDM (Adaptive Pulse Density Modulation) LED driver, operates over a 3V ~ 5.5V input voltage range. The device provides 12 open-drain constant current sinking outputs that are rated to 24V and delivers up to 60mA of high accuracy current to each string of LED. The current at each output is programmable by means of three external current setting resistors.

AL58221 features a 10MHz EMI reduction data clock input. AL58221 also offers a 2-wire serial interface to send the grayscale data, control command including 16/14/12/8-bit grayscale selection, grayscale clock frequency division selection, output polarity selection for high power LED driving, output Tr/Tf timing selection, current output waveform selection, and to realize the internal-latch function.

AL58221 provides adaptive pulse density modulation method to increase the visual refresh rate up to 1000 Hz @ 16-bit grayscale and reduce the flickers, and it also provides output current bilateral processing for EMI reduction.

AL58221 utilizes clock duty recovery technique and pulse re-timing to help long distance and multiple cascading applications. AL58221 provides typical  $\pm 1\%$  channel-to-channel LED current accuracy. Additional features include a  $\pm 0.1\%$  regulated output current capability and fast output transient response.

The device operates over  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$  ambient temperature range. The AL58221 is available in TSSOP-24EP.

### 2. Arduino UNO R3\_ microcontroller board

The Arduino UNO R3 is the best board to get started with electronics and coding. If this is your first experience tinkering with the platform, the UNO R3 is the most robust board you can start playing with. The UNO R333 is the most used and documented board of the whole Arduino family.

**Hardware description**

The AL58221 evaluation board as shown in Figure 3, : Top Section Description

, Table 1 and Table 2.

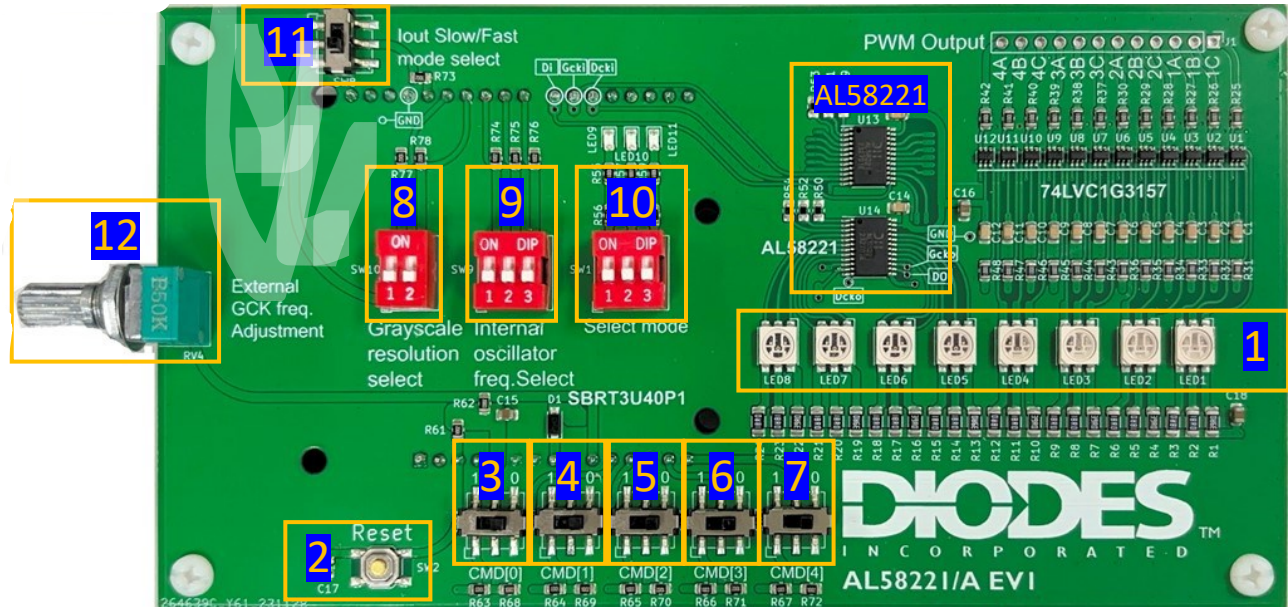


Figure 3: Top Section Description

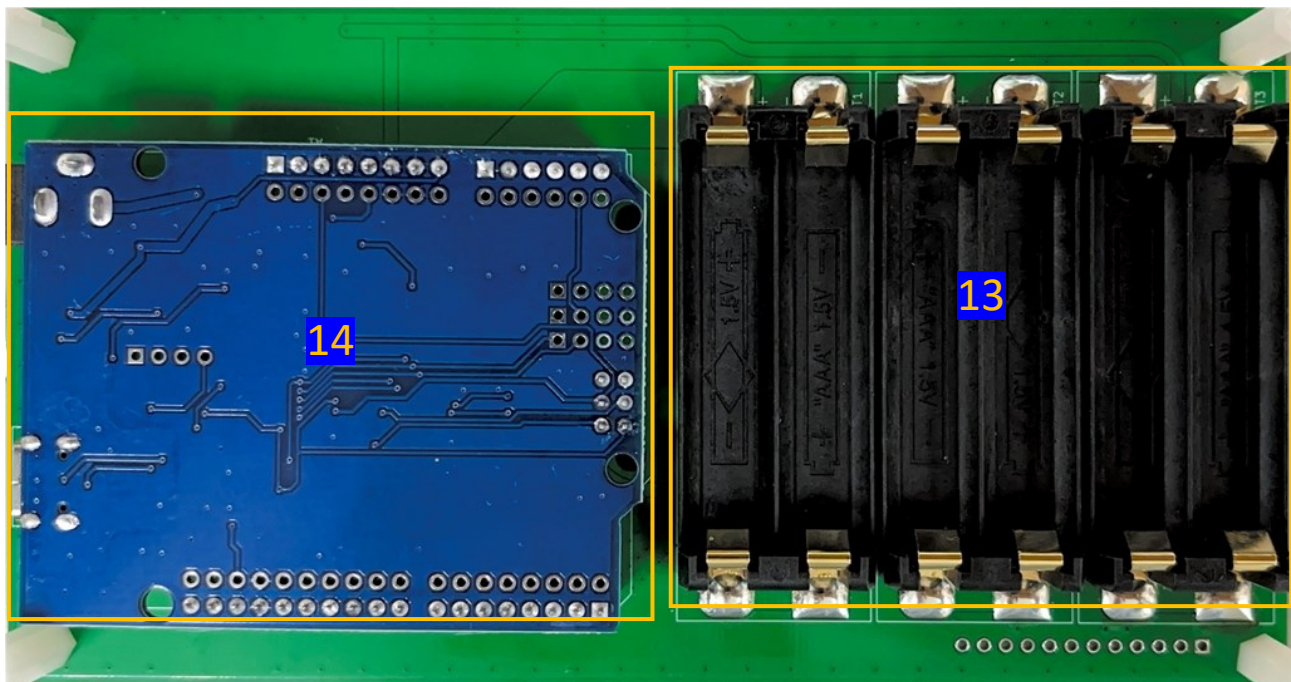


Figure 4: Bottom Section Description

Table 1: EVB Section Description

Section	Description
1	RGB LED Light Bar
2	System Reset Button
3	One-Shoot Select
4	Counter Reset Select
5	Output Polarity Select
6	Grayscale Clock Source Select
7	Output Waveform Select
8	Grayscale Resolution Select
9	Internal Oscillator Frequency Select
10	Reserved
11	I <sub>OUT</sub> Slow/Fast Mode Select
12	External GCK Frequency Adjustment
13	AAA dry batteries box
14	Control board- Arduino UNO

Table 2: Function Select summary table

Section	Components Name	AL58221 Bit No.	Description
3	SW3	CMD [0]	One-shoot Select (Right= '0', Left= '1') 0: Repeat Mode: Frame cycle continuous repeat. 1: One-Shoot Mode: Frame cycle is executed only once (One-Shoot Mode only usable when CMD[1] = '1')
4	SW4	CMD [1]	Counter Reset Select (Right= '0', Left= '1') 0: Free running mode 1: Counter reset mode (Only usable when CMD [3] = '1')
5	SW5	CMD [2]	Output Polarity Select (Right= '0', Left= '1') 0: work as LED driver 1: work as MY-PWM/APDM generator
6	SW6	CMD [3]	Grayscale Clock Source Select (Right= '0', Left= '1') 0: Internal oscillator (8.6MHz) (internal GCK source) 1: External clock from GCK1 pin (external GCK source RV4) If CMD [3] = '1', set CMD [7:5] = '000'
7	SW7	CMD [4]	Output Waveform Select (Right= '0', Left= '1') 0: MY-PWM output waveform 1: APDM output waveform
8	SW10	CMD [9:8]	Grayscale Resolution Select (Bottom= '0', Top='1') 00: 8-bit grayscale application 01: 12-bit grayscale application 10: 14-bit grayscale application 11: 16-bit grayscale application
9	SW9	CMD [7:5]	Internal Oscillator Frequency Select (Bottom= '0', Top='1') 000: Frequency= 8.6MHz                      001: Frequency= 8.6MHz / 2 010: Frequency= 8.6MHz / 4                011: Frequency= 8.6MHz / 8 100: Frequency= 8.6MHz /16               101: Frequency= 8.6MHz / 64 110: Frequency= 8.6MHz / 128            111: Frequency= 8.6MHz / 256 If CMD [3] = '1', set CMD [7:5] = '000'
11	SW8	CMD [10]	I <sub>OUT</sub> Slew-Rate Tr/Tf Select (Bottom= '0', Top='1') 0: I <sub>OUT</sub> slow Tr/Tf mode 1: I <sub>OUT</sub> fast Tr/Tf mode
12	RV4	-	External GCK Frequency Adjustment Virtual External GCK Frequency Knob from 7KHz to 170KHz

## Power Supply Options:

The device features two power supply options:

1. Utilizing six AAA dry batteries for portable convenience.
2. Connecting the ARDUINO control board via the USB interface (type C) to serve as the power source.

**Note: The two power supply methods cannot be used simultaneously.**

## Quick Start Guide

Once the power is connected to the AL58221 EVB, the RGB LED strip will display the following present sequences repeatedly.

1. Red, green, and blue will fade in and out sequentially as shown in Figure 5.
2. Red, yellow, green, blue, and purple will transition smoothly in gradients as shown in Figure 6.
3. A colorful marquee light display will be shown as depicted in Figure 7.

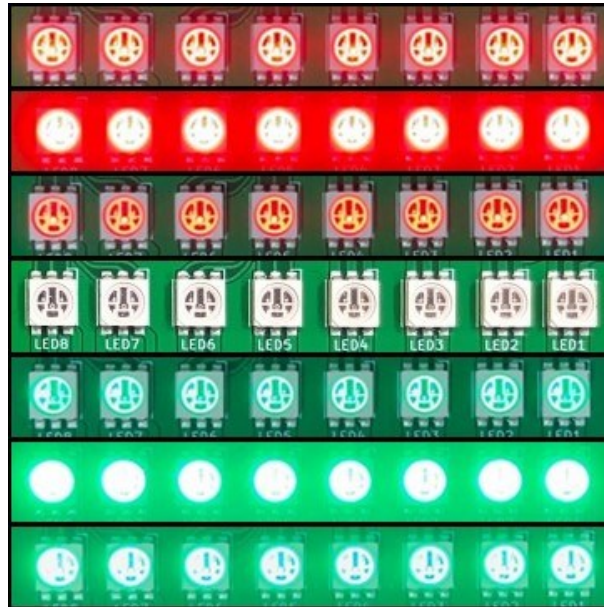


Figure 5: Fade in/out display

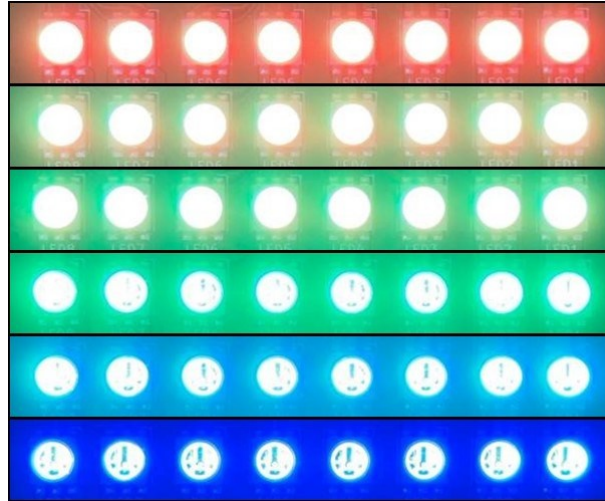


Figure 6: Gradient display



Figure 7: Marquee light display

This development board can switch between various functions using a toggle switch. All functions are summarized in Table 2, detailed description is as follows:

### 1. CMD [0]: One-shot select

This option is suitable for designs requiring strict synchronization of LED changes, as shown in

Figure 8.

- When CMD [0] = '0' enter Repeat Mode. After the LED PWM data is stored, the current PWM output will cycle automatically without stopping.
- When CMD [0] = '1' enter One-Shoot Mode. After the LED PWM data is stored, the current PWM output will stop automatically after executing this data.

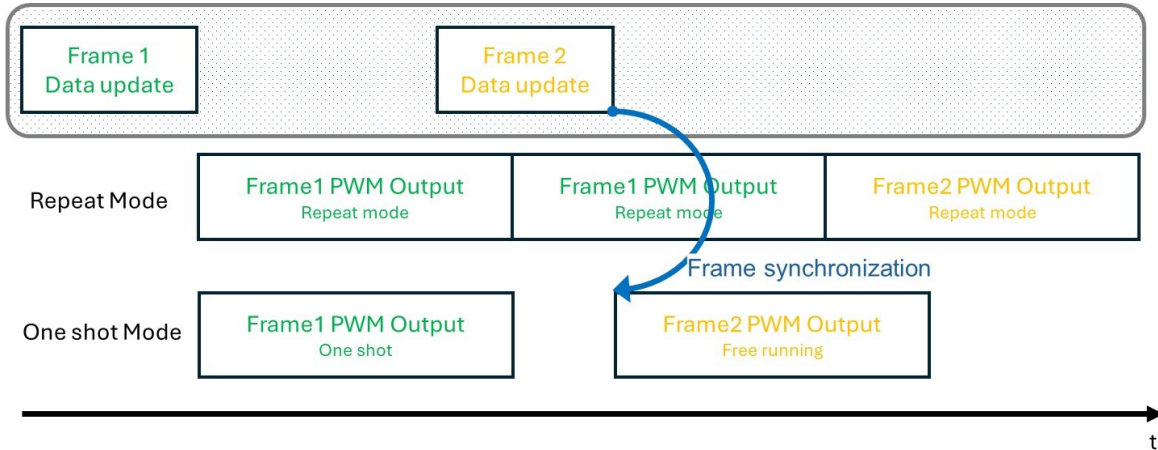


Figure 8: One-shot select

**2. CMD [1]: Counter Reset Select**

For the counter reset function, this option is suitable for designs requiring strict synchronization of LED changes, as shown in Figure 9. When frame 2 data is updated, the current PWM output is immediately reset.

- When CMD [1] = '0', it enters Free Running mode, and the current PWM output runs freely without control.
- When CMD [1] = '1', it enters Counter Reset mode, allowing the current PWM output to be forcibly reset, but this is only valid when CMD [3] = '1'.

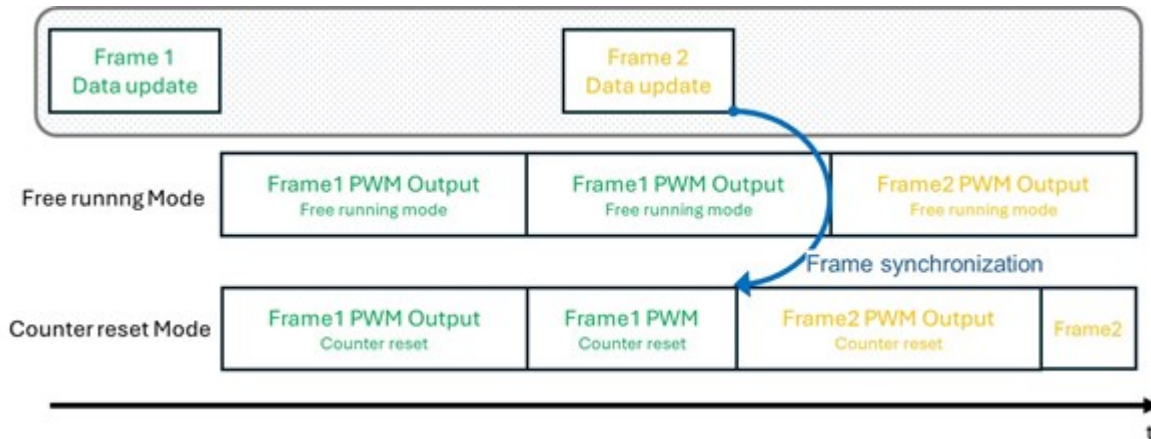


Figure 9: Counter Reset Select

**3. CMD [2]: Output Polarity Select**

This option is used to distinguish between directly driving LEDs or using as a PWM generator to drive high-power drivers, such as DC/DC.

- When CMD [2] = '0', current output waveform is not inverted, suitable for directly driving LEDs
- When CMD [2] = '1', current output waveform is inverted, suitable for designs using as a PWM generator.



#### 4. CMD [3]: Grayscale Clock Source Select

This option can be used to reduce the number of control lines or for designs with strict synchronization requirements for LEDs.

- When CMD [3] = '0', use internal frequency to reduce the use of external control signal lines.
- When CMD [3] = '1', use external frequency, suitable for designs requiring precise LED synchronization (external GCK source RV4). If CMD [3] = '1', set CMD[7:5] = '000'.

#### 5. CMD [4]: Output Waveform Select

This option provides a choice between continuous and dispersed current output. Continuous, non-dispersed setting is suitable for high-power drivers, while dispersed output is suitable for low-power direct drive designs.

- When CMD [4] = '0', The output current waveform is continuous and non-dispersed, suitable for high-power LED drivers.
- When CMD [4] = '1', The output current is dispersed, achieving a higher refresh rate.

#### 6. CMD [9:8]: Grayscale Resolution Select

Users can select the desired grayscale level based on product requirements. Lower grayscale levels are suitable for applications requiring a high frame rate.

- When CMD [9:8] = '00', into 8-bit grayscale application
- When CMD [9:8] = '01', into 12-bit grayscale application
- When CMD [9:8] = '10', into 14-bit grayscale application
- When CMD [9:8] = '11', into 16-bit grayscale application

#### 7. CMD [7:5]: Internal Oscillator Frequency Select

Different refresh rates can be achieved by selecting different internal frequencies.

- When CMD [7:5] = '000', oscillator frequency = 8.6MHz
- When CMD [7:5] = '001', oscillator frequency = 8.6MHz /2
- When CMD [7:5] = '010', oscillator frequency = 8.6MHz /4
- When CMD [7:5] = '011', oscillator frequency = 8.6MHz /8
- When CMD [7:5] = '100', oscillator frequency = 8.6MHz /16
- When CMD [7:5] = '101', oscillator frequency = 8.6MHz /64
- When CMD [7:5] = '110', oscillator frequency = 8.6MHz /128
- When CMD [7:5] = '111', oscillator frequency = 8.6MHz /256

#### 8. CMD [10]: IOOUT Slew-Rate Tr/Tf Select

Improving EMI can be achieved by changing the rise and fall slew-rate of the current.

- When CMD [10] = '0', I<sub>OUT</sub> slow Tr/Tf mode
- When CMD [10] = '1', I<sub>OUT</sub> fast Tr/Tf mode

## Software Programming Procedure:

1. Connect USB -C cable from PC/Laptop to Demo board (Remove battery)

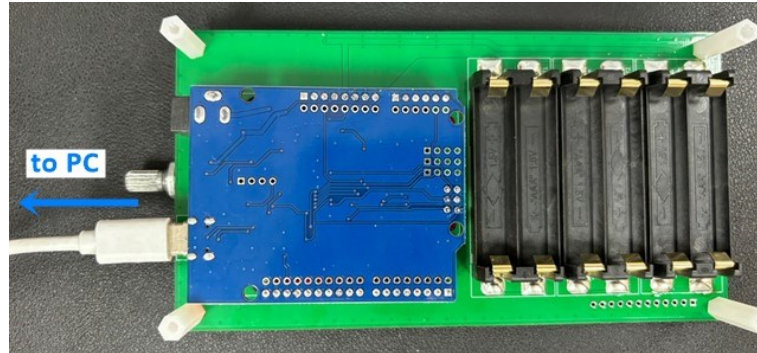


Figure 10: USB-C connection

2. Download the latest version of the Arduino IDE from the official Arduino website.
3. Item 『File』 -> 『Open』 , Importing an Arduino programming language file with 『.ino』 extension.
4. Click 『Select Board』 dialog box and search keyword 『UNO』 . Select 『UNO』 ( confirm that the file name of the existing version is correct )

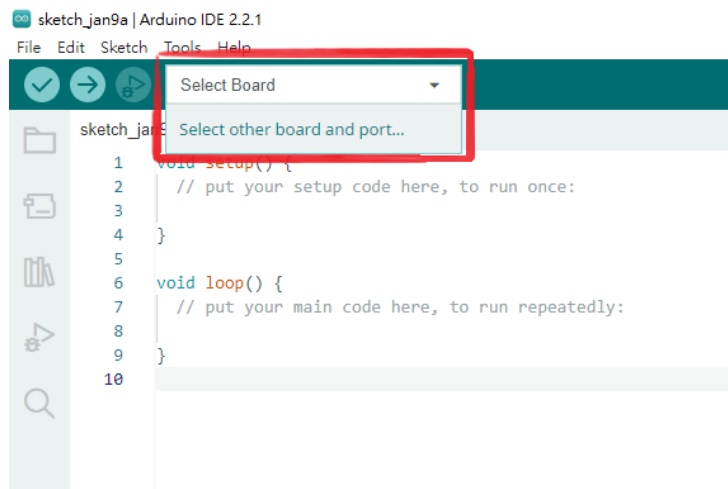


Figure 11: Select 『UNO』 control board

5. Select item 『Sketch』 -> 『Upload』 , uploading it to the control board.

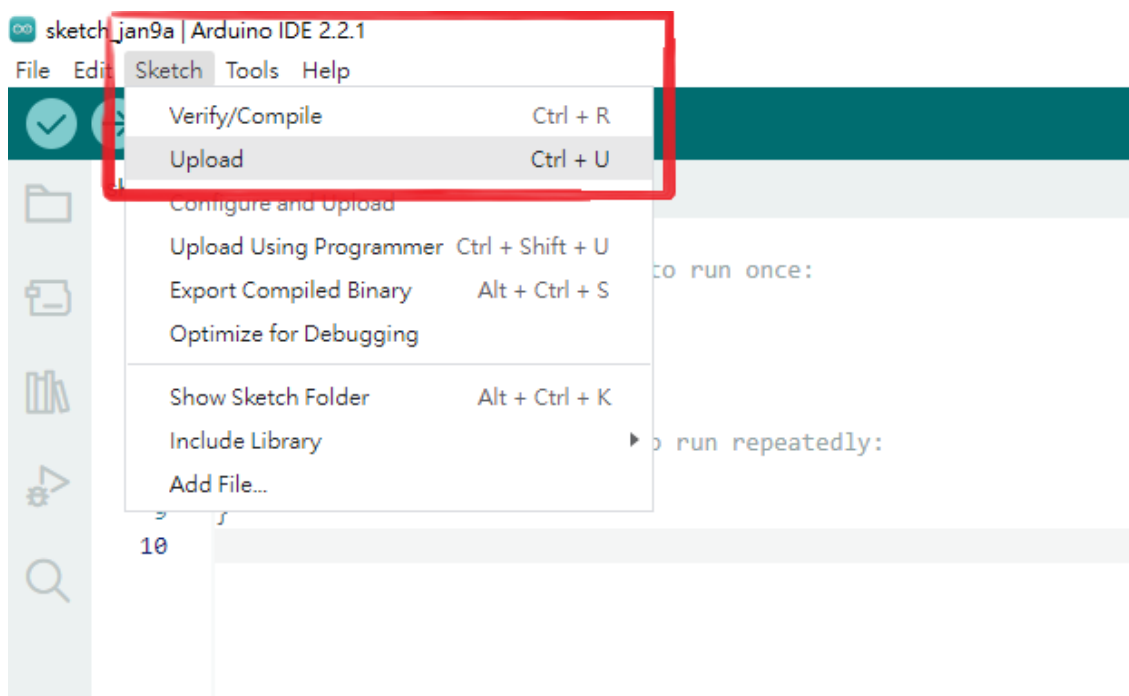


Figure 12: Uploading to the control board

**Evaluation Board Schematic**

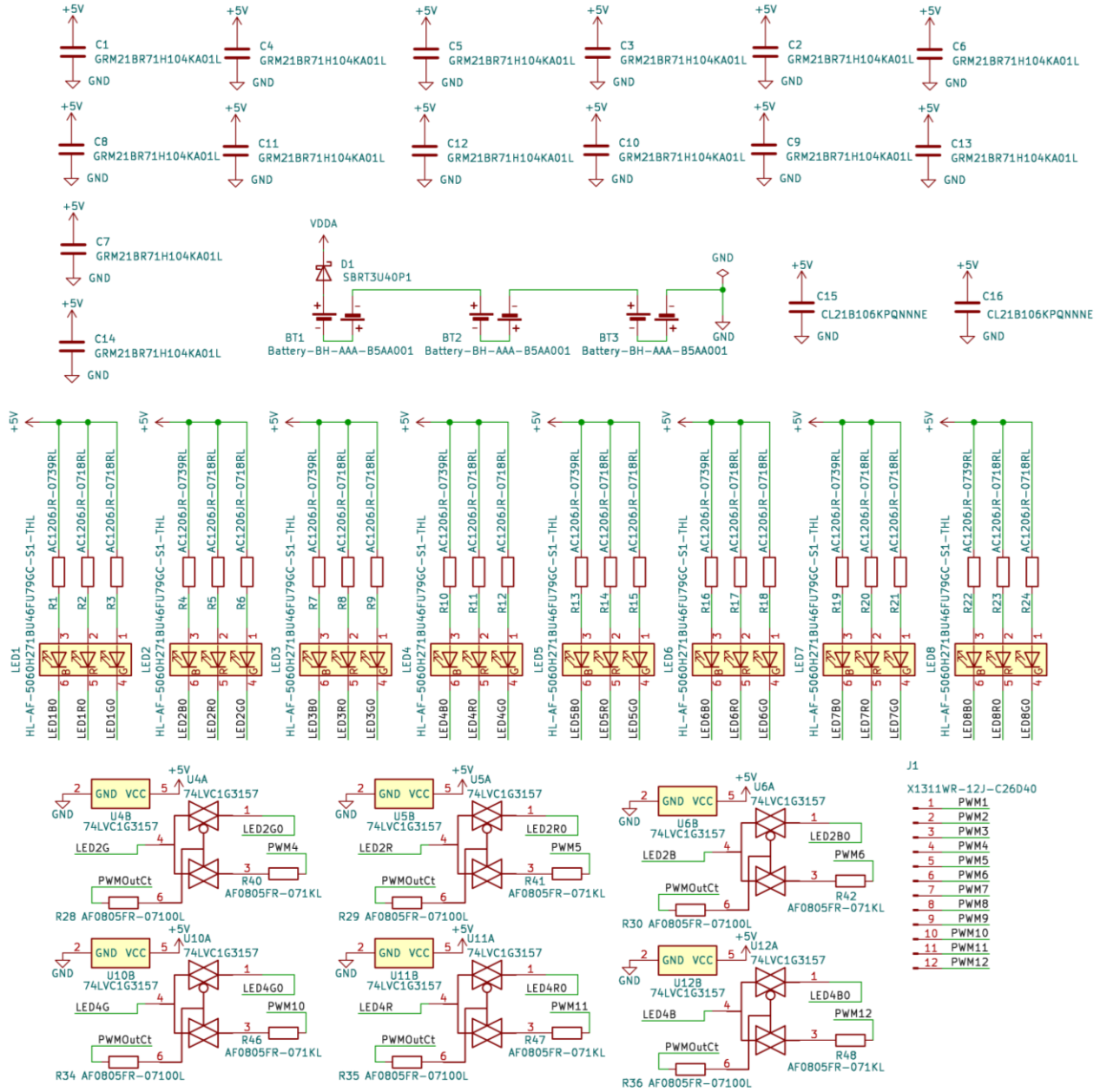


Figure 13: Evaluation Board Schematic 1

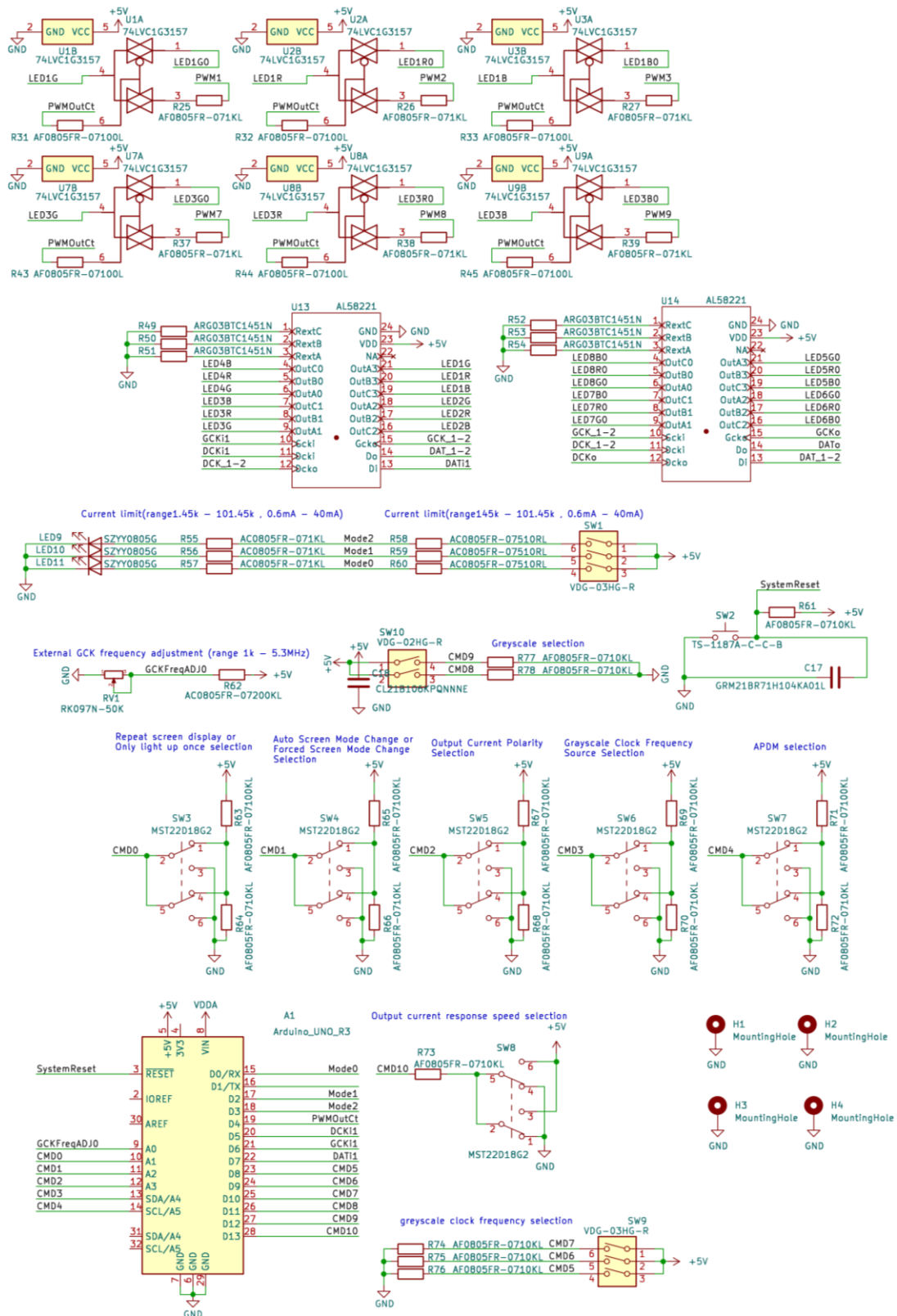


Figure 14: Evaluation Board Schematic 2

**Evaluation Board Layout**

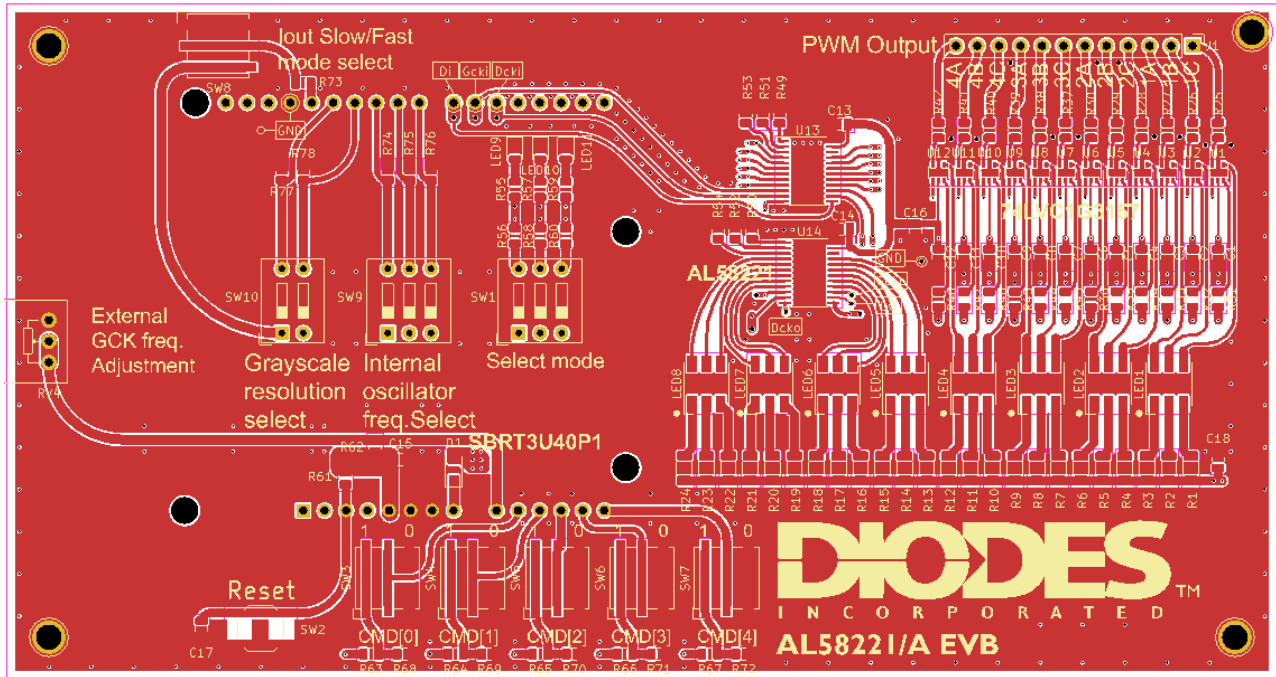


Figure 15: PCB Top Layer View

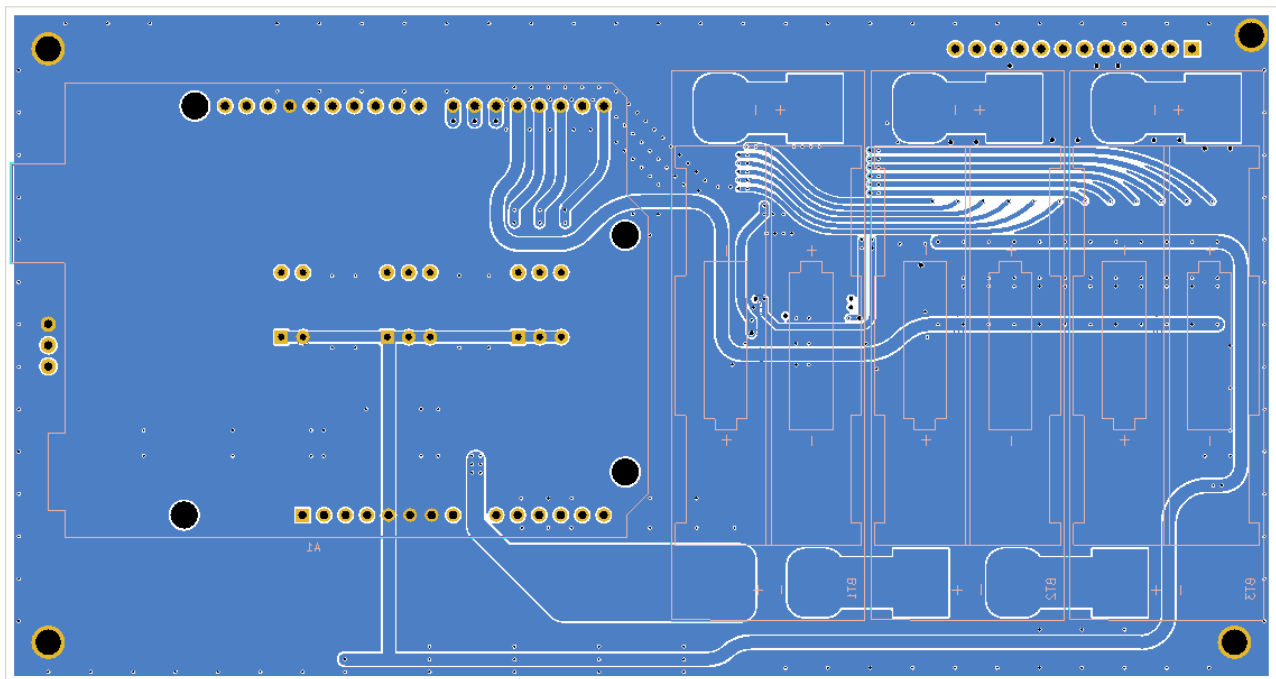


Figure 16: PCB Button Layer View

## Bill of Material

Location	Description	Manufacturer	Part Number	Package
U13, U14	12-Channel RGB LED Driver	Diodes Inc	AL58221	TSSOP-24EP
D1	3A TRENCH SBR, 40V Reverse Voltage	Diodes Inc	SBRT3U40P1-7	PowerDI123
U1, U2, U3, U4, U5, U6, U7, U8, U9, U10, U11, U12	SINGLE-POLE DOUBLE-THROW ANALOG SWITCH, 6Ω (typical) at VCC = 4.5V	Diodes Inc	74LVC1G3157	SOT363
LED1, LED2, LED3, LED4, LED5, LED6, LED7, LED8	SMD RGB LED, IF= 20mA	HONGLI TRONIC	HL-AF-5060H271BU46F U79GC-S1-THL	5.4*5mm
LED9, LED10, LED11	SMD Green LED, IF= 5mA	Yongyu Photoelectric	SZYY0805G	0805
BT1, BT2, BT3	Battery Holder	MYOUNG	BH-AAA-B5AA001	-
C1, C2, C3, C4, C5, C6, C7, C8, C9, C10, C11, C12, C13, C14, C17	Capacitor SMD, 0.1uF/50V X7R	Murata Electronics	GRM21BR71H104KA01L	0805
C15, C16, C18	Capacitor SMD, 10uF/10V X7R	Samsung Electro-Mechanics	CL21B106KPQN NNE	0805
R2, R3, R5, R6, R8, R9, R11, R12, R14, R15, R17, R18, R20, R21, R23, R24	Resistor SMD, 18Ω 5%, 1/4 W	YAGEO	AC1206JR-0718RL	1206
R25, R26, R27, R28, R29, R30, R37, R38, R39, R40, R41, R42	Resistor SMD, 1kΩ 1%, 1/8 W	YAGEO	AF0805FR-071KL	0805
R31, R32, R33, R34, R35, R36, R43, R44, R45, R46, R47, R48	Resistor SMD, 100Ω 1%, 1/8 W	YAGEO	AF0805FR-07100RL	0805

R61, R68, R69, R70, R71, R72, R73, R74, R75, R76, R77, R78	Resistor SMD, 10kΩ 1%, 1/8 W	YAGEO	AF0805FR-0710KL	0805
R1, R4, R7, R10, R13, R16, R19, R22	Resistor SMD, 39kΩ 5%, 1/4 W	YAGEO	AC1206JR-0739RL	1206
R49, R50, R51, R52, R53, R54	Resistor SMD, 1.45kΩ 0.1%, 1/10 W	Viking	ARG03BTC1451N	0603
R63, R64, R65, R66, R67	Resistor SMD, 100kΩ 1%, 1/8 W	YAGEO	AF0805FR-07100KL	0805
R55, R57, R59	Resistor SMD, 1kΩ 1%, 1/8 W	YAGEO	AC0805FR-071KL	0805
R56, R58, R60	Resistor SMD, 510Ω 1%, 1/8 W	YAGEO	AC0805FR-07510RL	0805
R62	Resistor SMD, 200kΩ 1%, 1/8 W	YAGEO	AC0805FR-07200KL	0805
SW3, SW4, SW5, SW6, SW7, SW8	Slide Switches, SMD, SW_SPST_SKQG	SHOU HAN	MST22D18G2	SMD 3.6x9.1
SW1, SW9	3 Bit SPST DIP Switches	Cixi Tonver Elec	VDG-03HG-R	DIP-4
SW2	Button Switch	XKB Connection	TS-1187A-C-C-B	5.1*5.1mm
SW10	2 Bit SPST DIP Switches	Cixi Tonver Elec	VDG-02HG-R	DIP-4
RV4	50K Ohm Variable Resistors	-	RK097N-50K	-
A1	Arduino_UNO_R3	-	-	-



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