ET- iLED-RGB

ET-TFT-iLED-RGB is Module LED RGB No.WS2812B with bit high resolution up to 24 Bit Color RGB; it means that it can display up to 16 million colors and it can be serially connected together at least 1024 Module as Cascade Connection without any increase circuit. It only uses single cable as NZR Communication to interface and control the operation. It sends Data as Serial type; it may be either Data 0 or 1 depending on the result of setting Period that is the same as Signal Pulse, it uses 1 Signal Period per 1 Bit Data to set the value either to be Data 0 or 1. The Module can support Input Data as TTL 5V; so, it can be used with MCU 5V and the Power Supply for board must be DC 5V only.

1. Specifications of Module ET-iLED-RGB

- Use DC 5V to supply Module
- Input DI supports Signal TTL 5V; so, it can be used with MCU 5V
- Use single cable for Serial NZR Communication to Control Interface Module; moreover, it also uses single cable to control Module Cascade connection
- Internal Chip WS2812B includes Signal Reshaping Circuit, Drive Circuit, Pixel RGB Controlling Circuit, Electric Reset Circuit, and Power Lose Reset Circuit
- White LED 1 Module (Color=0xFFFFFF) consumes the Current 60mA or 0.3W approximately
- 1 Module includes primary color that is RGB with a high resolution at 24Bit Color. Each color displays 256 shades of brightness, so 1 LED can display 16,777,216 shades of color by using scanning frequency not less than 400 Hz/s
- The gulf between 2 Modules while connecting Signal Data Control can be more than 5m without any increase circuit.
- When using rate of Refresh at 30 fps, it can connect at least 1024 LEDs together as Cascade Connection.
- Sending data in each bit as Serial type at a speed of 800 Kbps
- Color of this LED is highly consistent light and Output of LED is Late type, it keeps glowing until other new set of Data is sent out.

2. Structure of Module ET-iLED-RGB

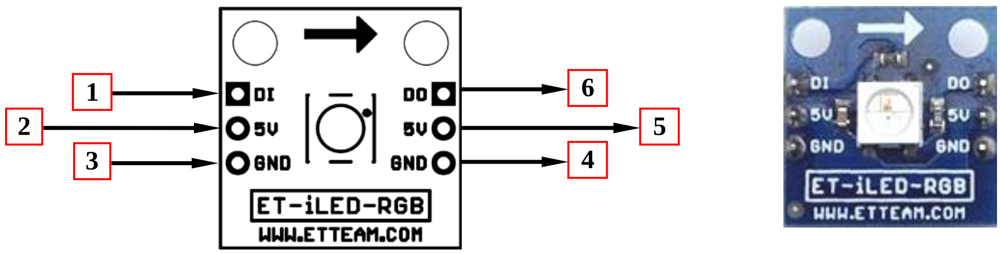


Figure shows pin position of Module ET-iLED-RGB.

1 = DI: Pin INPUT receives Serial Data Bit Color support Signal TTL 5V

6 = DO: Pin Output sends Serial Data Bit Color to Pin DI of the next Module

2 = 5V: Power Supply DC 5V for Board

5 = 5V: Pin Power Supply 5V for the next Module

3 = GND: Ground

4 = GND: Pin Ground is connected to Pin Ground of the next Module

***Arrow on Module shows direction of connecting with the next Module as Cascade Connection.**

3. Operation of Module ET-iLED-RGB

Initially, user needs to create 3 types of signal that are Signal Logic 0, Logic 1, and Signal RESET. These 3 Signal types are related to ON/OFF time of signal, read more information about format of signal in section of Control. After created Signal Logic successfully, user needs so send Logic according to the preferable Data Bit Color to Pin DI of Module as serial type bit by bit; in this case, it has to totally send 24Bit Color. This Bit Color is arranged in the format of RGB and the first bit is sent out is Bit MSB. After all 24Bit or 1 Frame is sent out completely, it has to follow by Signal RESET and the LED will glow instantly according to the specified color. In summary, the way to control 1 LED is to consist of 24Bit Color (1 frame)+Signal RESET.

If connecting more than 2 Modules LED Cascade, amount of Bit Data Color that user send out must be equal to amount of Module or amount of the connective LED. As mentioned above, it has to send 24Bit Data Color or 1 Frame for 1 LED; if connecting 5 LEDs, it has to send 5 Frames of Data Color consecutively and the distance between Frames must be not less than 50 us. In this case, Data Color of each Frame that is sent out can be the same color or different color as preferred. After sent Data Color of all 5 Frames successfully, it has to end with Signal RESET; and finally, all 5 LED are glowed instantly according to the specified colors. Remember, the color that is sent out to the first Frame belongs to the LED1; the color of the second Frame belongs to the LED2 in the Cascade Connection and so on. It keeps respectively sending color to Frames in the Cascade Connection according to the amount of the connective LED; so, the way to control the connective LED as Cascade Connection is amount of Frame Color that user sends out must be equal to amount of connective LED+Signal RESET.

The operation in the part of this Cascade Connection starts when the LED1 received all 24Bit Color (frame1) completely; it remembers and acknowledges the status. Next, when the second Bit Color is sent out (frame2), the LED1 ignores this Data Bit and passes by to Pin DO in order to send this data set to Pin DI of the LED2; in this case, the LED2 will accept and receive this data bit color of the second frame, and it remembers and acknowledges this status. Next, when the third Data Bit Color (frame3) is sent out, both LED1 and LED2 ignore this data bit because the Bit Acknowledge internal LED has already been setup, so Data of frame3 is sent out to LED3. If any Signal RESET has not been sent out yet, it is still sending out Data Bit Color in each frame to each LED in the Cascade Connection continuously and respectively. After sent all frame data completely according to amount of the connective LED, user needs to send out Signal RESET to end and LED will be glowed according to the specified color. Moreover, status of Bit Acknowledge of all LED will be cleared, it means that if user sends any additional frame color after Signal RESET, data of the frame color will be received by the first LED again. Remember, amount of data frame color that user needs to send out must be equal to amount of the connective LED and it must be ended up by Signal RESET. When it sends out Data in each frame, it must take less than 50us otherwise LED acknowledges the Data as Signal RESET and the data frame color is received by the first LED again; it makes LED receive Data incompletely, so the display of LED is also mistake.

NOTE: To reduce heat of PCB occurred while running LED, user should not turn on white light (ON) for a long time.

4. How to Interface with MCU and Control ET-iLED-RGB

4.1) **Connection**: This circuit uses MCU AVR Mega 128, 16 MHz Clock to be Controller by using Board ET-Base AVR ATmega128 r3 and it refers to ETT's examples for testing. It uses SPI's resource of AVR to control and it uses Pin PB2(MOSI) to create Signal Logic 0, 1 and RESET in order to send to Module LED.

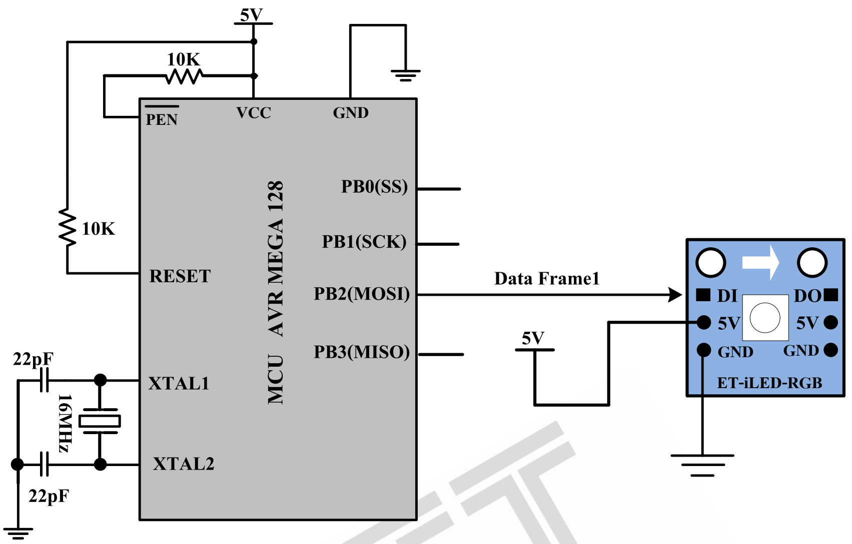


Diagram shows the connection of MCU AVR Mega128, Control Module ET-iLED-RGB as Single Module.

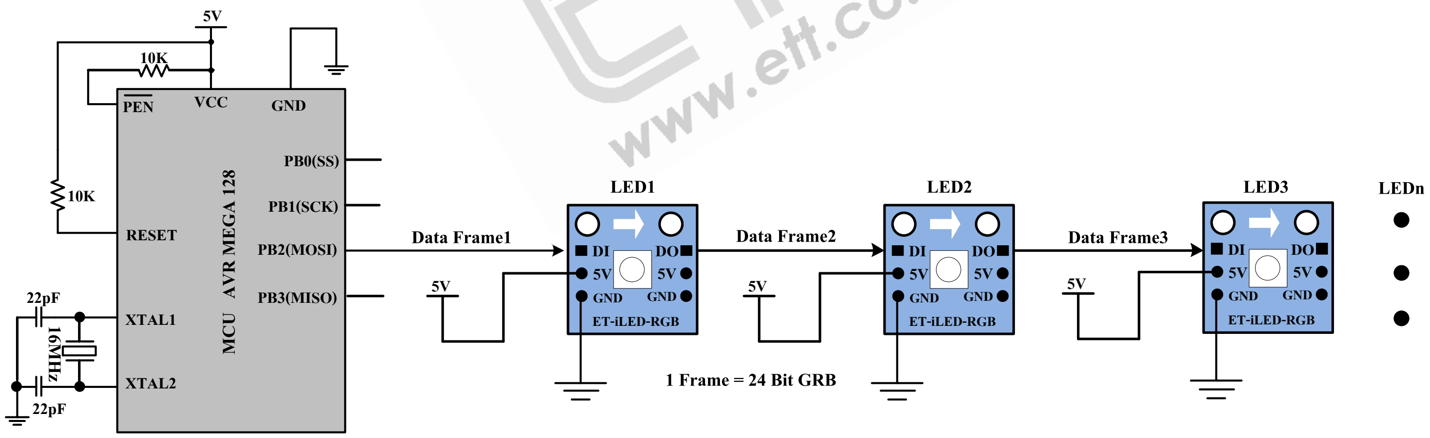


Diagram shows the connection of MCU AVR Mega128, Control Module ET-iLED-RGB as Cascade Connection.

<u>*NOTE*</u>: When connecting many Modules LED together as Cascades Connection, user should carefully consider Power Supply for Modules, it must have enough current to supply modules; in this case, LED 1 Module consumes 60mA Current approximately.

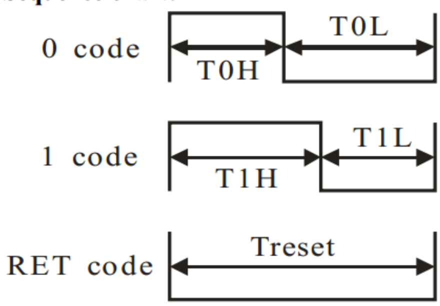
4.2) **Control**: Now, it refers to ETT's examples to control this ET-iLED-RGB. The essential of this control is the way to create Signal Logic 0, 1, and RESET, it depends on the ability of user and resource of MCU that has enough and can support the requirements of MCU or not. Refer to the ETT's examples, it sends Data of SPI to create signal as described below;

1) Initially, write program to create Signal Logic 0, 1, and RESET; the feature of signals must be the same as the Sequence Chart below;

Data transfer time(TH+TL=1.25µs±150ns)

T0H	0 code ,high voltage time	0.35us	±150ns
T1H	1 code ,high voltage time	0.9us	±150ns
T0L	0 code , low voltage time	0.9us	±150ns
T1L	1 code ,low voltage time	0.35us	±150ns
RES	low voltage time	Above 50µs	

Sequence chart:



Referred to the diagram above,

Logic 0: User needs to create 1 Signal Period at 1.25 us ± 150 ns; Positive Period(+) (T0H) = 350 ns ±150 ns and Negative Period(–) (T0L) = 900 ns ± 150ns. This signal is sent out instead of Logic 0 1-Bit Data.

Logic 1: User needs to create 1 Signal Period at 1.25 us ± 150 ns; Positive Period(+) (T1H) = 900 ns ±150 ns and Negative Period(–) (T1L) = 350 ns ± 150ns. This signal is sent out instead of Logic 1 1-Bit Data.

RESET: User needs to create 1 Signal Period at 1.25 us ± 150 ns; Negative Period(-) is greater than 50 us. This signal is sent out instead of RESET.

Referred to ETT's example, it creates these signals by sending Data of SPI as described below (referred to AVR Mega128 at 16 MHz Clock)

- Initially, it calculates SCK of SPI for sending Data; SCK divided by 2 is 8 MHz, it means that it takes 1/8Mhz = 125 ns for sending 1-Bit Data of SPI. When divided by 2, the result of calculating Period to create Signal Logic 0, 1, and RESET is in the specified Period. Moreover, user can initial SPI by setting Connector Clock (CPOL) and Phase Clock (CPHA) = 1.
- Set Data SPI that will be sent out to create Signal Logic 0, 1. When sending SPI one time, it sends out 8-Bit Data to Pin MOSI; it takes 125ns for sending 1-Bit Data and the first bit it sends out is Bit7. Data SPI that creates Logic 0 is 0xC0; it sets Bit 7 and Bit 6 as 1 amount 2-Bit, the Positive Period(+) is 125ns x 2 = 250ns; and it sets Bit 5..Bit 0 as 0 amount 6Bit, the Negative Period(-) is 125ns x 6 = 750ns. Referred to the both Periods, it is in the specified range of Code 0; so, sending Data SPI by 0xC0 one time, it has replaced in sending 1-Bit Data Logic0 to Module LED. Meanwhile, Data SPI that creates Logic 1 is 0xFC; it uses the same principle as mentioned above, so sending Data SPI by 0xFC one time, it has replaced in sending 1-Bit Data Logic1 to Module LED. For Signal RESET, user only sends Data SPI by 0x00 and the setup Delay higher than 50 us, and finally user gets Signal RESET as required.

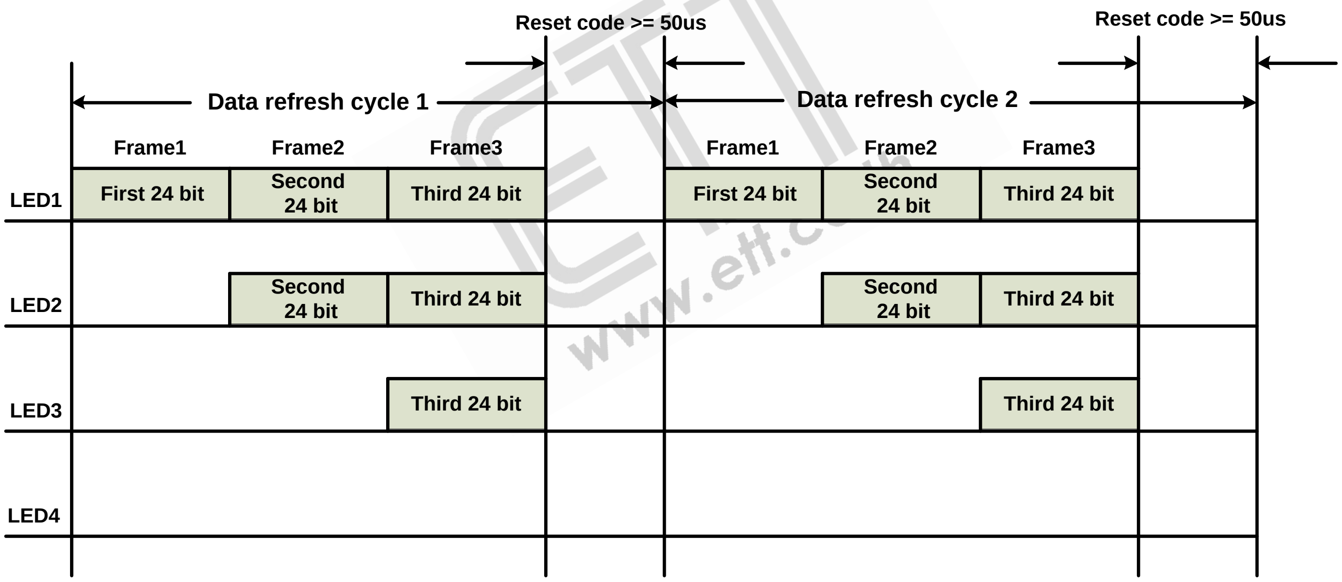
2) Write function in the part of sending 24Bit Data Code Color to Pin DI of Module LED. When it sends out 1 Period that may be either Code 0 or 1 according to Chart above, it means that it sends out 1-Bit that may be either Data 0 or 1 to Module LED. The 24-Bit Code Color that is sent out is arranged as RGB type as shown in the table below. The first bit it sends out is Data Bit MSB.

Composition of 24bit data:

G7	G6	G5	G4	G3	G2	G1	G0	R7	R6	R5	R4	R3	R2	R1	R0	B7	B6	B5	B4	B3	B2	B1	B0

Note: Follow the order of GRB to sent data and the high bit sent at first.

3) Write function for sending Frame Data. When it sends out Data 1 Frame, it means that it sends 24-Bit Data Color in the section 2 above. When it sends out this Data 1 Frame, it specifies color for 1 LED; so, amount of Frame that is sent out in each time must be equal to amount of all connective LEDs in the Cascade connection. The first Frame that is sent out is to specify color for LED1; the second Frame is sent out is to specify color for LED2 in the Cascade connection, and so on. After sent Frame completely according to amount of the connective LED, it always ends by Signal RESET; any Frame that is sent out after Signal RESET starts specifying color for the first LED again. The diagram below illustrates how to write this function.



4) After user wrote the main functions above completely, user can write program to command Module instantly. For ETT's example, it receives color value from user in the format of RGB because it is standard of color arrangement but it has to alternate color bit to be GRB before sending out to Module LED.

***NOTE**: When choosing MCU Control Module LED, user should choose high speed MCU and consider how to create Signal Logic 0, 1 and RESET; referred to the example, the way to create Signal Logic 0, 1 and RESET is to send Data of SPI to create Signal Logic. However, MCU sometimes runs at high speed but it cannot setup frequency to supply operation needs of Signal Logic. As mentioned above, there is no any problem about writing program to create Signal Logic in order to control 1 LED, but be careful about writing program to control many LEDs in Cascade Connection because speed of sending each Frame Data Color is irregular. The distance between Frames must be less than 50us. If the distance between Frames is higher than 50us, it seems that it sends out Signal RESET; it makes the first LED return to receive new Frame again but it has not completely sent Frame yet according to amount of the connective LED; so, some connective LED are glowed and some LED display strange color.*

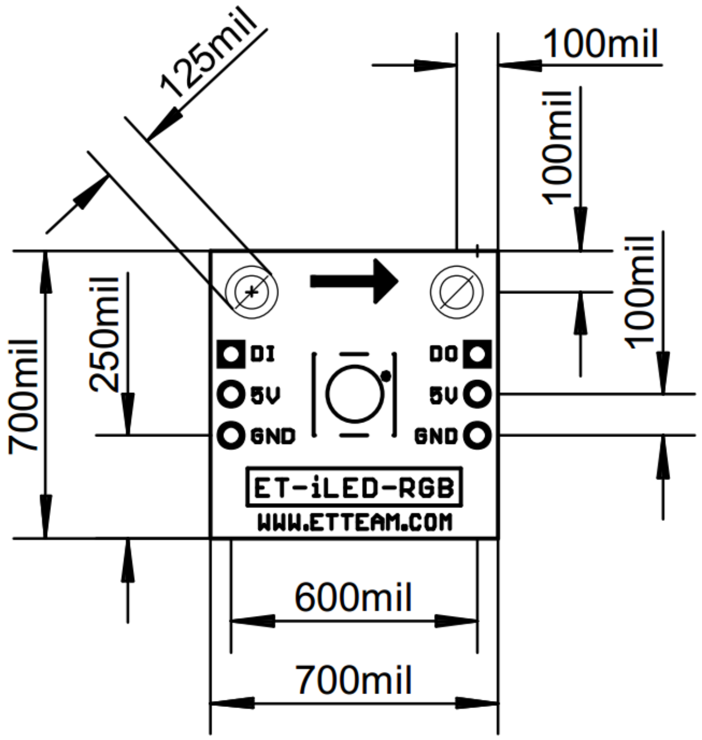


Figure shows size of Module ET-iLED-RGB (1 mil = 0.0254mm.).

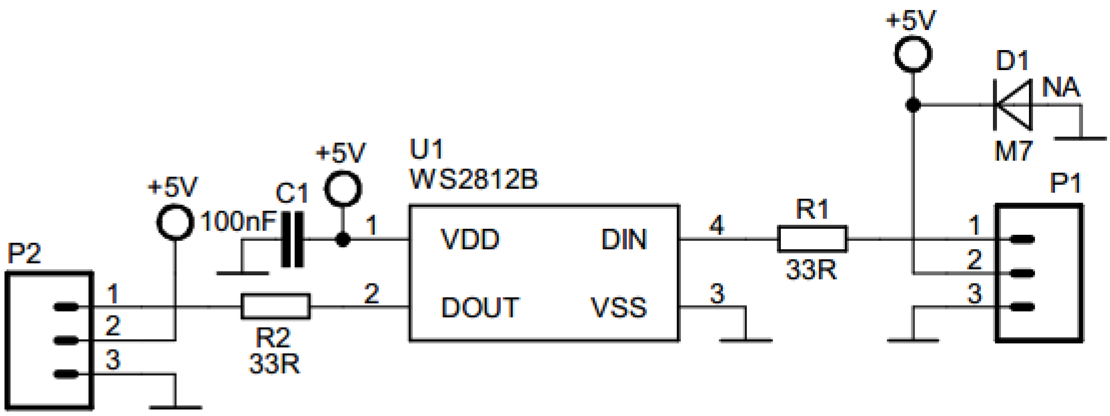


Figure shows Circuit Module ET-iLED-RGB (1 mil = 0.0254mm.).