

# Application Note

## LED Strip Effects Generator Using SLG46811V AN-CM-325

### Abstract

*This application note describes the design procedure of a serial data pattern generator for making visual effects with a chain of WS2812B addressable RGB LEDs, using the SLG46811V and its EPG 92-byte ROM module. This note also contains test results of the hardware prototype.*

*The application note comes complete with design files which can be found in the References section.*

---

---

---



---

**LED Strip Effects Generator Using SLG46811V**

## Contents

<b>Abstract</b> .....	<b>1</b>
<b>Contents</b> .....	<b>2</b>
<b>Figures</b> .....	<b>2</b>
<b>1 Terms and Definitions</b> .....	<b>3</b>
<b>2 References</b> .....	<b>3</b>
<b>3 Introduction</b> .....	<b>4</b>
<b>4 Address LED Controlling Techniques</b> .....	<b>4</b>
4.1 Hardware Protocol .....	4
4.2 Details of Color Forming .....	5
4.3 Software Protocol.....	5
4.4 Proposed Electrical Connection.....	5
<b>5 Internal Block Configuration</b> .....	<b>7</b>
5.1.1 "Zero and One" Code Generator .....	7
5.2 Multiplexing a Bitstream.....	8
5.2.1 EPG Configuration.....	10
<b>6 Tuning</b> .....	<b>10</b>
6.1 Address LED Data Timings.....	10
6.2 LED Count Tuning.....	11
<b>7 Normal Operation Mode</b> .....	<b>11</b>
<b>8 Conclusion</b> .....	<b>12</b>
<b>Revision History</b> .....	<b>13</b>

## Figures

Figure 1. PWM LED protocol.....	4
Figure 2. Time Diagram of 0 and 1 Coded Signals .....	4
Figure 3: LED Data Protocol.....	5
Figure 4. General Electrical Schematic .....	5
Figure 5. GreenPAK Design Structure .....	6
Figure 6. GreenPAK Designer Configuration .....	6
Figure 7. Oscillator Settings .....	7
Figure 8. Multiplexer Settings for 3-bit LUT0-LUT6.....	8
Figure 9. DFF Configuration .....	9
Figure 10. 3-bit LUT12 Configuration .....	9
Figure 11. EPG Configuration .....	10
Figure 12. Software Simulated Timing Diagram 1 .....	11
Figure 13. Software Simulated Timing Diagram 2 .....	11
Figure 14. Oscilloscope Output Pin Waveform .....	12
Figure 15. Working Prototype; Sequential Photos .....	12

---

---

## LED Strip Effects Generator Using SLG46811V

### 1 Terms and Definitions

DFF	D Flip-Flop
EPG	Extended Pattern Generator
IC	Integrated Circuit
LUT	Look-Up Table
LED	Light Emitting Diode
NVM	Non-Volatile Memory
RGB	Red Green Blue
Vcc	Voltage common collector, power supply pin

### 2 References

For related documents and software, please visit:

<https://www.dialog-semiconductor.com/products/greenpak>

Download our free **GreenPAK** Designer software [1] to open the .gp files [2] and view the proposed circuit design. Use the **GreenPAK** development tools [3] to freeze the design into your own customized IC in a matter of minutes. Find out more in a complete library of application notes [4] featuring design examples as well as explanations of features and blocks within the GreenPAK IC.

- [1] [GreenPAK Designer Software](#), Software Download and User Guide
- [2] [AN-CM-325 LED Strip Effects Generator Using SLG46811V.gp](#), [GreenPAK](#) Design File
- [3] [GreenPAK Development Tools](#), [GreenPAK](#) Development Tools Webpage
- [4] [GreenPAK Application Notes](#), [GreenPAK](#) Application Notes Webpage
- [5] SLG46811, Datasheet
- [6] GreenPAK Cookbook

Author: Svyatoslav Skalsky

## LED Strip Effects Generator Using SLG46811V

### 3 Introduction

The WS2812B is a popular intelligent RGB LED with a driver and a proprietary digital serial protocol for control. It is widely used to make LED strips for visual decorative effects or even to make simple LED screens. In this application note, we will introduce a basic design using the SLG46811 that will make a visual effect of running colors along the LED strip. 64 LEDs are soldered in a chain (an 8x8 matrix is used).

### 4 Address LED Controlling Techniques

There are several different techniques for controlling WS2812 LED strips. Different types of MCUs are used to implement these techniques. We are introducing a new way to program an LED strip using a configurable logic IC with NVM memory, the SLG46811 IC.

#### 4.1 Hardware Protocol

The WS2812B is a 5050-component package with a control circuit, drivers, and RGB LED. It also has signal reshaping and amplification circuit. Data is sent in a serial manner using a single pin from transmitter to receiver. Each LED is the transmitter of a signal received from the previous LED.

For programming LEDs, a serial bitstream of logical 0s and 1s should be transformed into pulse width modulated voltage levels (see Figure 1). The LEDs have a built-in signal form reshaping circuit, as they transmit a data sequence from the previous LED to the next one. After wave reshaping, they send all data to the next driver, ensuring waveform distortion will not accumulate. The timings are described in Figure 2.

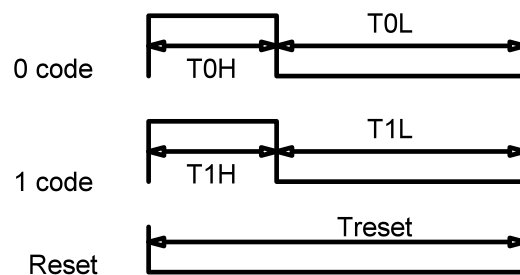


Figure 1. PWM LED protocol

Data transfer time ( $T_H+T_L=1.25\mu s\pm 600ns$ )

T0H	0 code, high voltage time	0.35 us	+150ns
T1H	1 code, high voltage time	0.7us	+150ns
T0L	0 code, low voltage time	0.8us	+150ns
T1L	1 code, low voltage time	0.6us	+150ns
Reset	Low voltage time	Above 50us	

Figure 2. Time Diagram of 0 and 1 Coded Signals

## LED Strip Effects Generator Using SLG46811V

### 4.2 Details of Color Forming

Each pixel of the three primary colors can have 256 brightness steps, completing a 16,777,216 color display with a scan frequency no less than 400 Hz.

### 4.3 Software Protocol

The RGB color code has 3 bytes received one after another, each byte coding 256 digits of the brightness of each LED. First the green byte is sent, then the red, then the blue (see Figure 3).

G	G	G	G	G	G	G	G	R	R	R	R	R	R	R	B	B	B	B	B	B	B	B	
7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0

Figure 3: LED Data Protocol

After receiving 3 RGB bytes, the LED controller repeats all the consecutive data received from an input pin to a data output pin.

When the low-level signal is held throughout the period > 50 us, all the received data is latched and displayed by the LEDs.

### 4.4 Proposed Electrical Connection

A signal pin should never have a higher voltage than Vcc. It is recommended to connect a resistor from data out pin 6 of the SLG46811 to an LED data input pin.

It is also recommended to connect all the LED Vcc pins and the SLG46811 Vcc pin in parallel to preserve this condition. A small capacitor (100 nF) is required across each LED Vcc-GND pin (see Figure 4).

The simplified GreenPAK configuration scheme is shown in Figure 5.

The simplified GreenPAK design structure of the SLG46811 pattern generator as configured by GreenPAK Designer is shown in Figure 6.

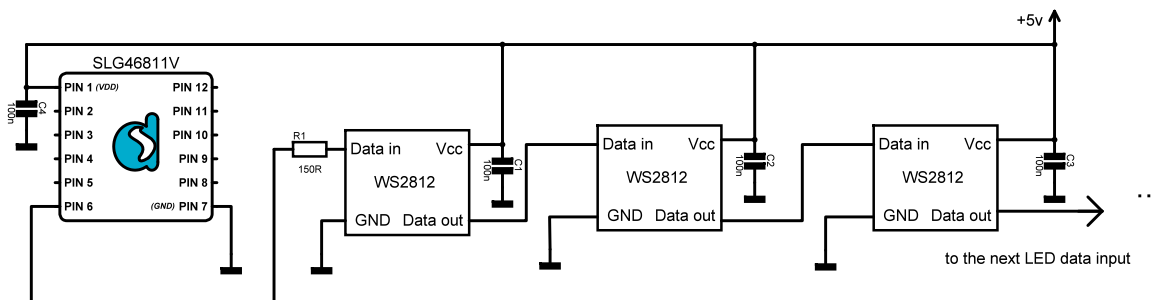


Figure 4. General Electrical Schematic

LED Strip Effects Generator Using SLG46811V

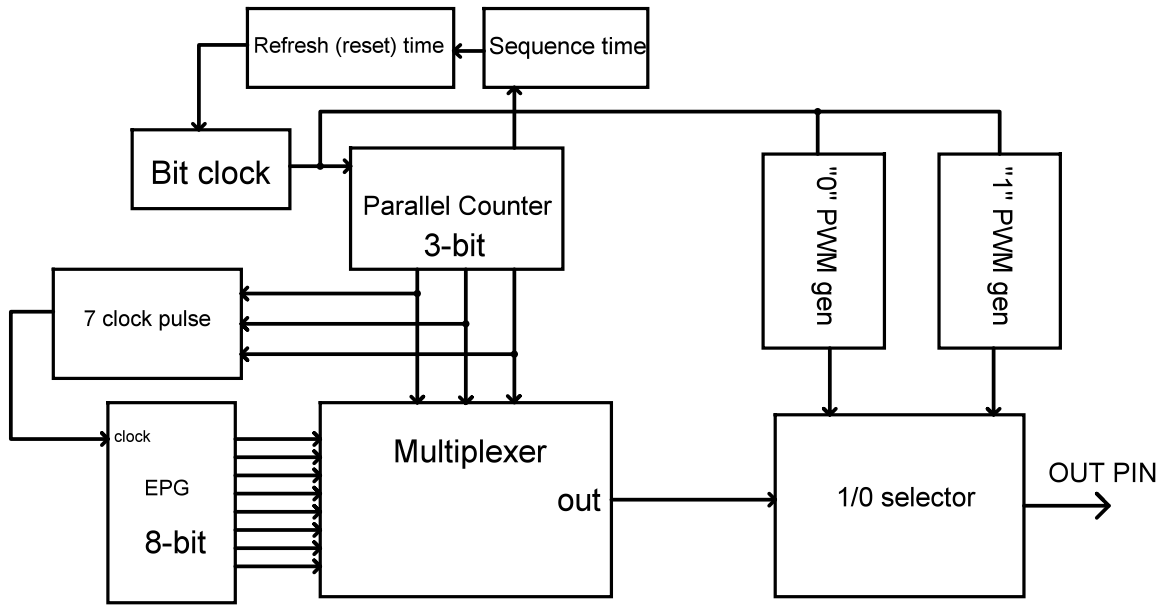


Figure 5. GreenPAK Design Structure

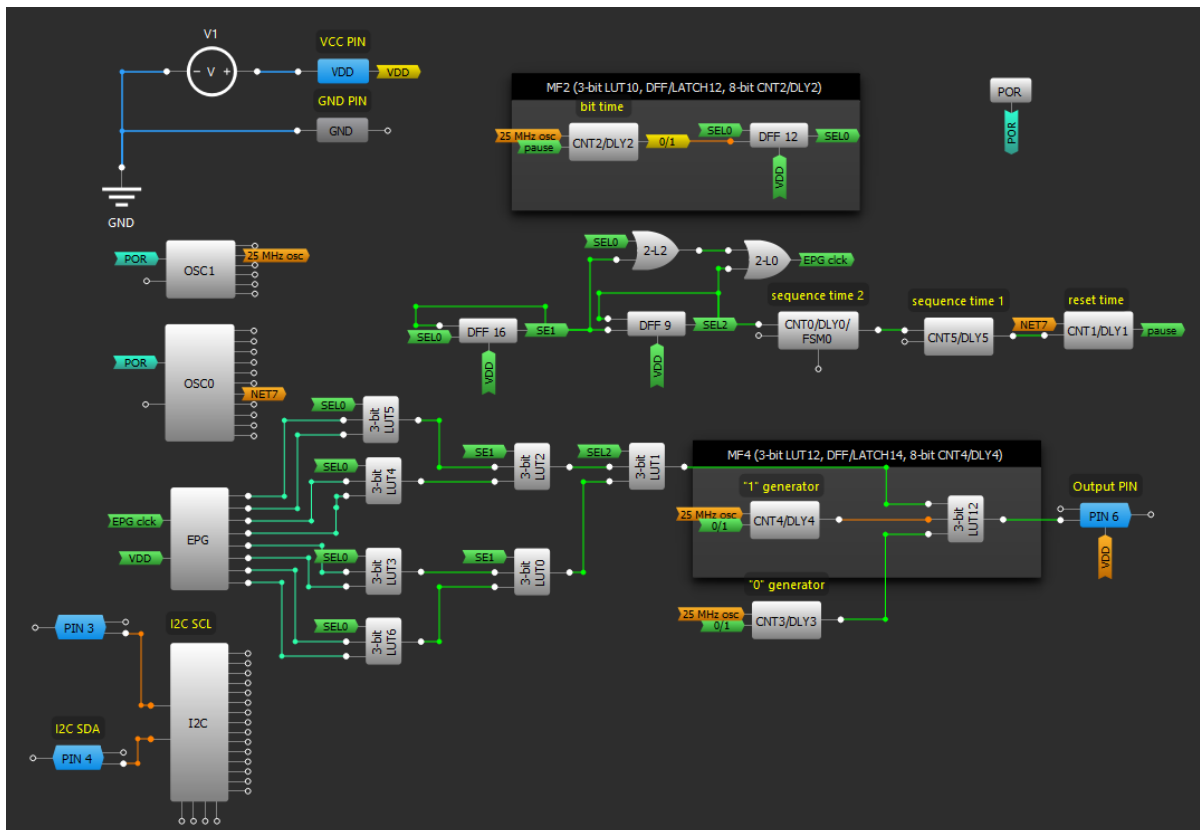


Figure 6. GreenPAK Designer Configuration

## LED Strip Effects Generator Using SLG46811V

### 5 Internal Block Configuration

The proposed pattern generator is based on the SLG46811 IC. The internal oscillators OSC0 and OSC1 are configured to output  $2.048\text{kHz}/8=256\text{Hz}$  and  $25\text{MHz}$  respectively (see Figure 7).

**Properties OSC0**

Control pin mode: Power down

Power down input: Disable

OSC power mode: Auto Power On

Clock selector: OSC

'OSC0' frequency: 2.048 kHz

'CLK' predivider by: 1

'OUT0' second divider by: 1

'OUT1' second divider by: 1

**Information**

Frequency

**Clock output configuration:**

RC OSC Output	Value
OUT0	OSC0 Freq.
OUT1	OSC0 Freq.
CLK	OSC0 Freq.
CLK /2	OSC0 Freq. /2
CLK /4	OSC0 Freq. /4
CLK /8	OSC0 Freq. /8
CLK /12	OSC0 Freq. /12
CLK /24	OSC0 Freq. /24
CLK /64	OSC0 Freq. /64
CLK /512	OSC0 Freq. /512
CLK /4096	OSC0 Freq. /4096

Apply

**Properties OSC1**

Control pin mode: Force on

Power down input: Disable

OSC power mode: Force Power On

Clock selector: OSC

'OSC1' frequency: 25 MHz

'CLK' predivider by: 1

'OUT' second divider by: 1

Start with delay: Enable

**Information**

Frequency

**Clock output configuration:**

RC OSC Output	Value
OUT	OSC1 Freq.
CLK /4	OSC1 Freq. /4
CLK /8	OSC1 Freq. /8
CLK /64	OSC1 Freq. /64
CLK /512	OSC1 Freq. /512

Apply

Figure 7. Oscillator Settings

#### 5.1.1 "Zero and One" Code Generator

To form a PWM with a fixed high-level time, the 8-bit CNT3 and CNT4 counter blocks are configured for 280ns and 880ns high-level period time. CNT2 is used to form a total 1.24us one shot time. DFF12, DFF16, and DFF9 counts to 8 bits forming a byte impulse. CNT0 and CNT5 together count up to 279 bytes, which fills all the LEDs with information bits from the EPG plus an extra 3 bytes to create a shift effect. For example, 92 bytes from the EPG are sent three times in a row ( $92 \times 3 = 279$  bytes) including 3 bytes extra to make the shift effect. Each LED takes 3 bytes from a bitstream, thus 93 LEDs can be addressed. CNT1 generates a reset pause for latching all the transmitted bytes into LEDs and represents a limit of display refresh rate (which limits the visual velocity of a string movement). CNT1's 15ms delay time will result in 66 frames per second.

LED Strip Effects Generator Using SLG46811V

5.2 Multiplexing a Bitstream

The 3-bit LUT0-LUT6 form a multiplexer, which transforms a byte from the EPG to serial bits for output.

All multiplexer LUTs have the same configuration setting shown in Figure 8.

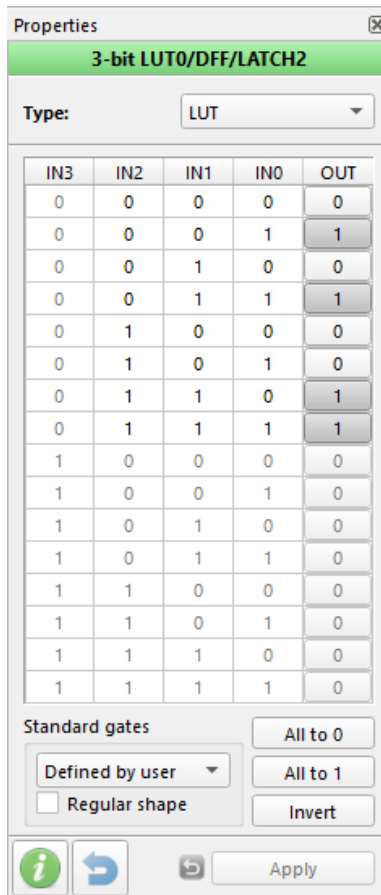


Figure 8. Multiplexer Settings for 3-bit LUT0-LUT6

DFF9, DFF16, and DFF12 form a 3-bit parallel counter, which addresses the multiplexer. The address is reset every byte pulse through reset inputs. The DFFs are all configured as a D flip-flop with inverted output, as shown in Figure 9.



LED Strip Effects Generator Using SLG46811V

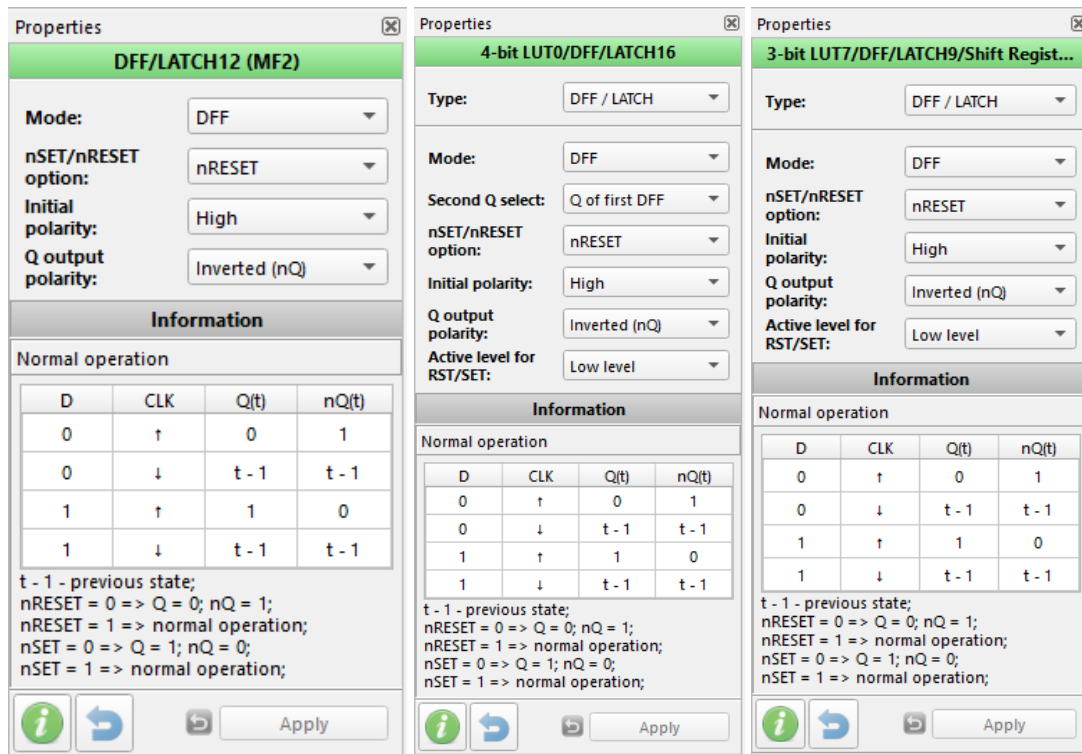


Figure 9. DFF Configuration

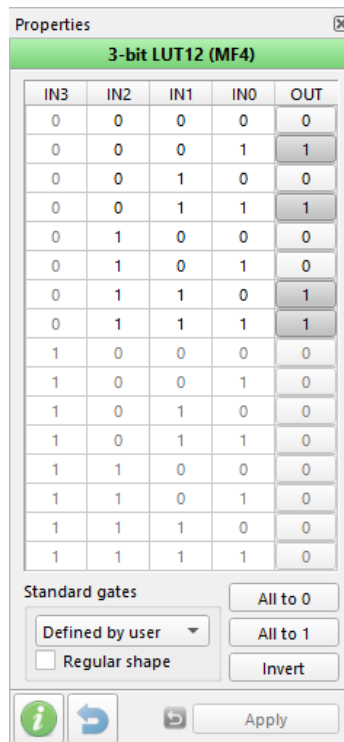


Figure 10. 3-bit LUT12 Configuration

The 3-bit LUT12 selects which 0 or 1 PWM pulse to pass through to the output pin 6. The design has DFF15 configured to work as an edge detector. The configuration is shown in [Figure 10](#).

## LED Strip Effects Generator Using SLG46811V

### 5.2.1 EPG Configuration

The extended pattern generator (EPG) is configured for an overflow action: after all 92 bytes are clocked out, the generator is reset to the byte 0 (see Figure 11). In this design we are addressing 61 LEDs, so we are clocking the EPG two times in a row. It would be ideal to address 92 LEDs to clock the EPG 3 times. In this case, CNT0 should be configured for 276 clocks ( $3 \times 92$ ) plus 3 bytes for a shift (running string effect), thus reaching 279 in total. Entering the sequence into the EPG, users should keep in mind that 90 bytes from the generator would address 30 LEDs and the 91-92 bytes will go to the 31st LED only for green and red color bytes. The next "overflowed" first byte from the EPG will go to the blue byte of the 31st LED. So the 31st LED will have a shift of 1 byte compared to the first run of the EPG. We have to program a sequence into the EPG to make a color shift.

The programmed EPG bytes are:

(0,0,8,0,0,16,0,0,24,0,0,32,0,0,40,0,0,48,0,0,56,0,0,64,0,0,72,0,0,80,0,0,88,0,0,96,0,0,104,0,0,112,0,0,128,0,0,136,0,0,142,0,0,150,0,0,158,0,0,164,0,0,172,0,0,180,0,0,188,0,0,196,0,0,204,0,0,212,0,0,220,0,0,228,0,0,236,0,0)

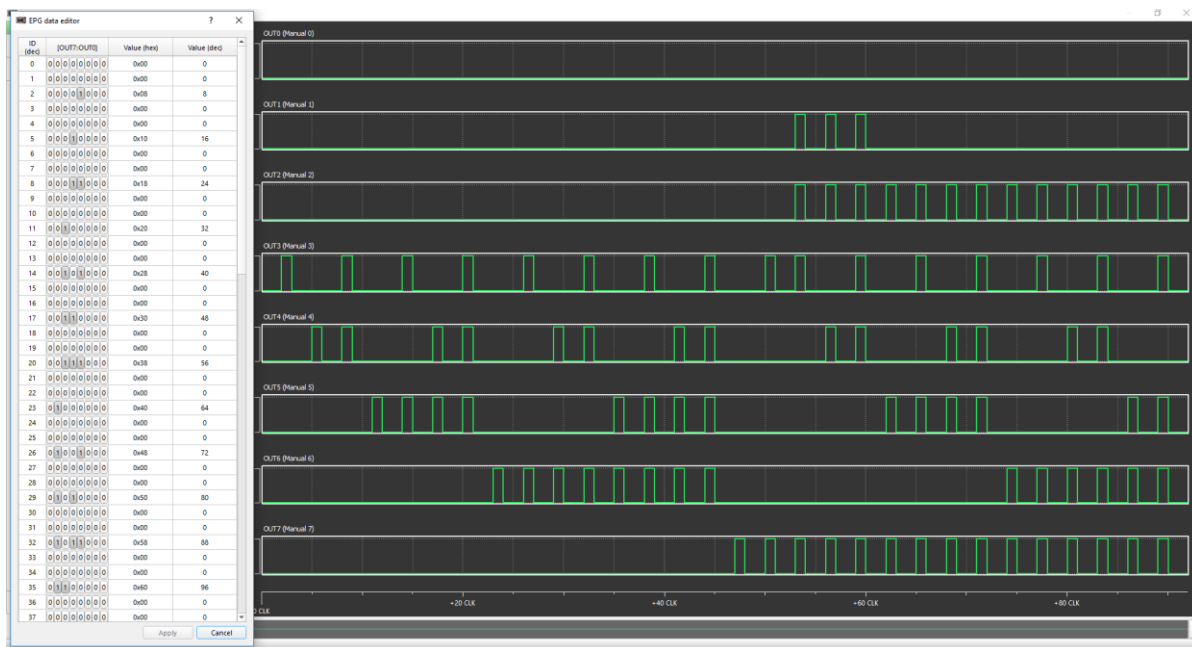


Figure 11. EPG Configuration

## 6 Tuning

### 6.1 Address LED Data Timings

There are many different modifications and manufacturers' standards of the WS2812B LED that can differ in data timings. The best way to figure out what period of 0s and 1s you should use is to set up the SLG46811 IC in emulation mode with typical settings, connect the LED chain, and measure timings retranslated from the next LED using an oscilloscope. Use those measurements to set up the CNT3, CNT4, and CNT2 counters as zero bit width time, one bit time, and bit period respectively.

## LED Strip Effects Generator Using SLG46811V

### 6.2 LED Count Tuning

If you want to have a greater number of LEDs than 93, you have to add 3 to the counter value of CNT0 (2 is for 93 LEDs, 5 will give you 186 LEDs, 8 will give you 279 LEDs, and so on).

## 7 Normal Operation Mode

After tuning the timings and programming the EPG with the desired sequence, the SLG46811 is ready for operation. Its timing diagram is shown in [Figure 13](#).

The oscilloscope waveform is shown in [Figure 14](#).

The working prototype series of photos is shown in [Figure 15](#).

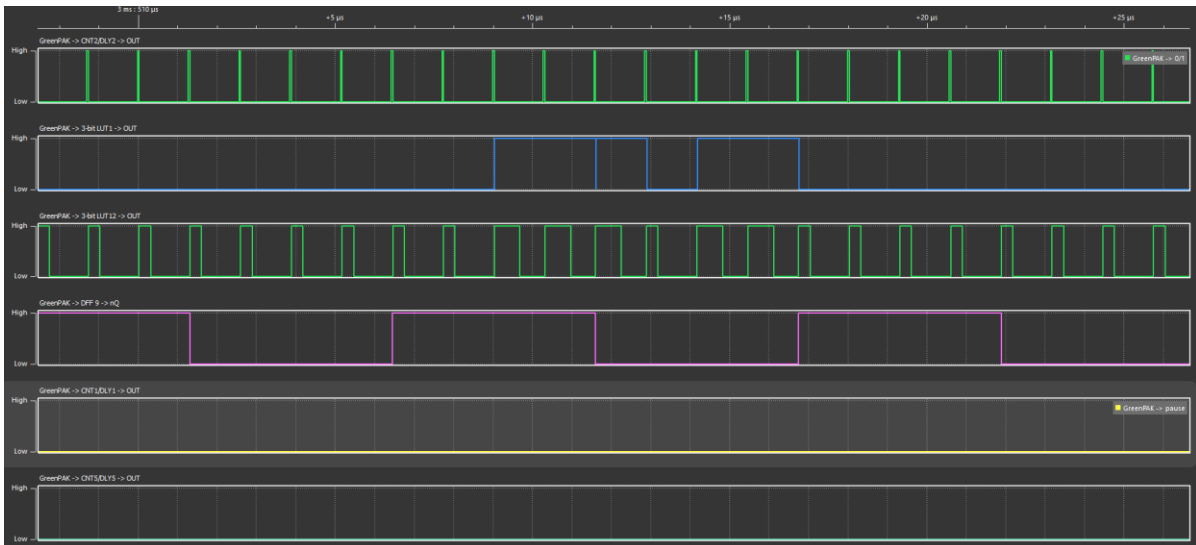


Figure 12. Software Simulated Timing Diagram 1

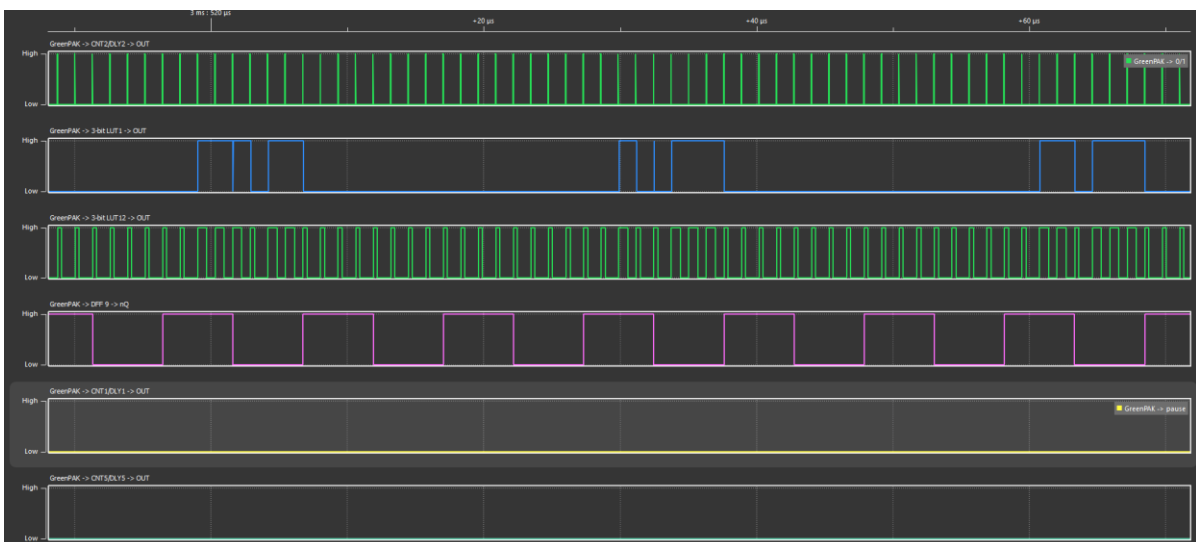


Figure 13. Software Simulated Timing Diagram 2

LED Strip Effects Generator Using SLG46811V

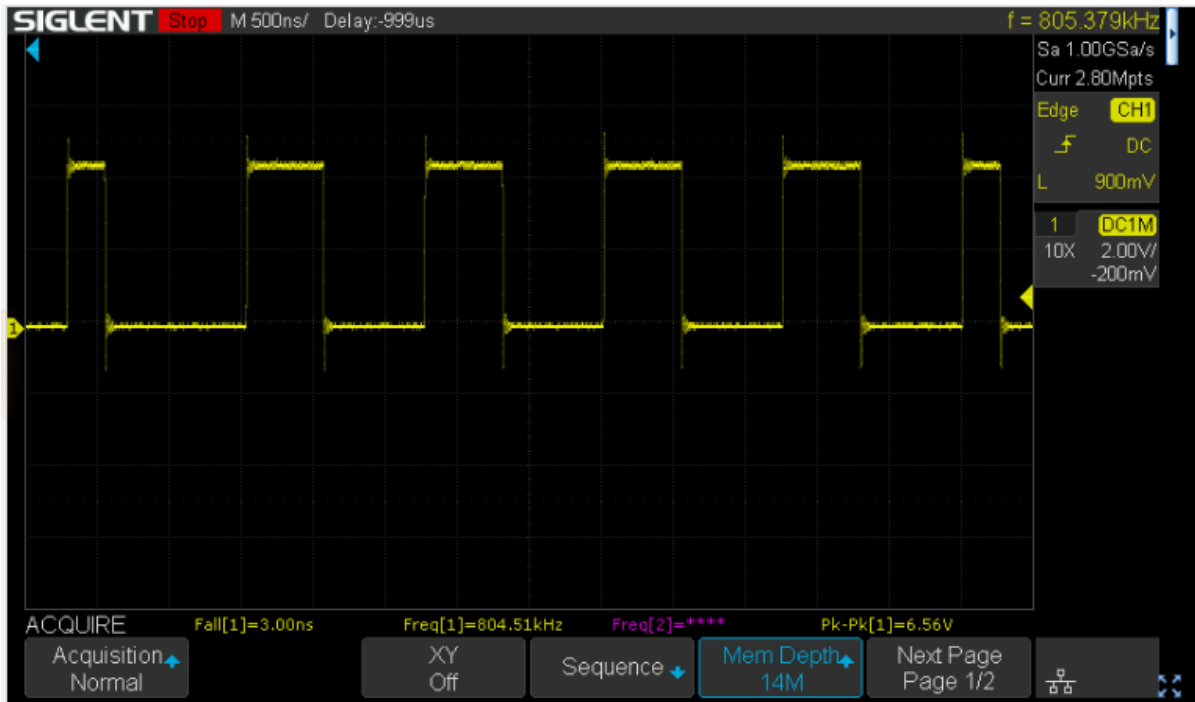


Figure 14. Oscilloscope Output Pin Waveform

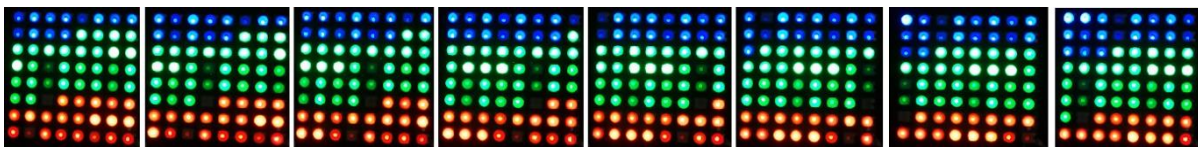


Figure 15. Working Prototype; Sequential Photos

## 8 Conclusion

The proposed pattern generator using the SLG46811 in conjunction with a chain of WS2812B LEDs can deliver a "running string" of colors for a decorative visual effect.

---

---

**LED Strip Effects Generator Using SLG46811V****Revision History**

<b>Revision</b>	<b>Date</b>	<b>Description</b>
1.0	08-Oct-2021	Initial version

## IMPORTANT NOTICE AND DISCLAIMER

RENESAS ELECTRONICS CORPORATION AND ITS SUBSIDIARIES (“RENESAS”) PROVIDES TECHNICAL SPECIFICATIONS AND RELIABILITY DATA (INCLUDING DATASHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES “AS IS” AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS OR IMPLIED, INCLUDING, WITHOUT LIMITATION, ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for developers skilled in the art designing with Renesas products. You are solely responsible for (1) selecting the appropriate products for your application, (2) designing, validating, and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, or other requirements. These resources are subject to change without notice. Renesas grants you permission to use these resources only for development of an application that uses Renesas products. Other reproduction or use of these resources is strictly prohibited. No license is granted to any other Renesas intellectual property or to any third party intellectual property. Renesas disclaims responsibility for, and you will fully indemnify Renesas and its representatives against, any claims, damages, costs, losses, or liabilities arising out of your use of these resources. Renesas' products are provided only subject to Renesas' Terms and Conditions of Sale or other applicable terms agreed to in writing. No use of any Renesas resources expands or otherwise alters any applicable warranties or warranty disclaimers for these products.

(Rev.1.0 Mar 2020)

### Corporate Headquarters

TOYOSU FORESIA, 3-2-24 Toyosu,  
Koto-ku, Tokyo 135-0061, Japan  
[www.renesas.com](http://www.renesas.com)

### Contact Information

For further information on a product, technology, the most up-to-date version of a document, or your nearest sales office, please visit:  
[www.renesas.com/contact/](http://www.renesas.com/contact/)

### Trademarks

Renesas and the Renesas logo are trademarks of Renesas Electronics Corporation. All trademarks and registered trademarks are the property of their respective owners.