

Rechargeable LED Flashlight

SLG47105

This application note describes how to create a Rechargeable LED Flashlight using HVPAK. The device has a powerful flashlight and a strobe mode. The Flashlight is powered by a 3.7 V Li-ion battery that is charged with Constant Current – Constant Voltage control circuit.

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

Contents

1. Terms and Definitions	1
2. References.....	2
3. Introduction	2
4. Construction and Operating Principle.....	3
5. GreenPAK Design	3
5.1 LED Control	3
5.2 CCCV Battery Charger	6
6. Conclusion	7
7. Revision History	8

1. Terms and Definitions

CC	Constant Current
CV	Constant Voltage
DC	Direct current
DFF	D Flip-Flop
OSC	Oscillator

2. References

For related documents and software, please visit:

<https://www.renesas.com/eu/en/products/programmable-mixed-signal-asic-ip-products/greenpak-programmable-mixed-signal-products/greenpak-high-voltage-programmable-mixed-signal-matrix>

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. Renesas provides a complete library of application notes [4] featuring design examples as well as explanations of features and blocks within the Renesas IC.

[1] [GreenPAK Designer Software](#), Software Download and User Guide, Renesas Electronics

[2] [AN-CM-367 Rechargeable LED Flashlight.hv](#), HVPK Design File, Renesas Electronics

[3] [GreenPAK Development Tools](#), GreenPAK Development Tools Webpage, Renesas Electronics

[4] [GreenPAK Application Notes](#), GreenPAK Application Notes Webpage, Renesas Electronics

[5] SLG47105 Datasheet, Renesas Electronics

[6] [AN-CM-363 CCCV Battery Charger](#), Renesas Electronics

3. Introduction

The main goal of this application is to design a Rechargeable LED Flashlight using the SLG47105V. The system is designed using the HV macrocells and other internal and external components within the GreenPAK to drive a 3 W LED as well as charging the battery. The Flashlight has two modes: the Flashlight and the Strobe Light.

This device is a rechargeable flashlight, powered by a 3.7 V Li-ion battery. The battery can be charged by any USB power adapter using implemented Constant Current – Constant Voltage (CCCV) charging method.



Figure 1: Rechargeable LED Flashlight

4. Construction and Operating Principle

The Full Circuit Schematic is shown in [Figure 2](#).

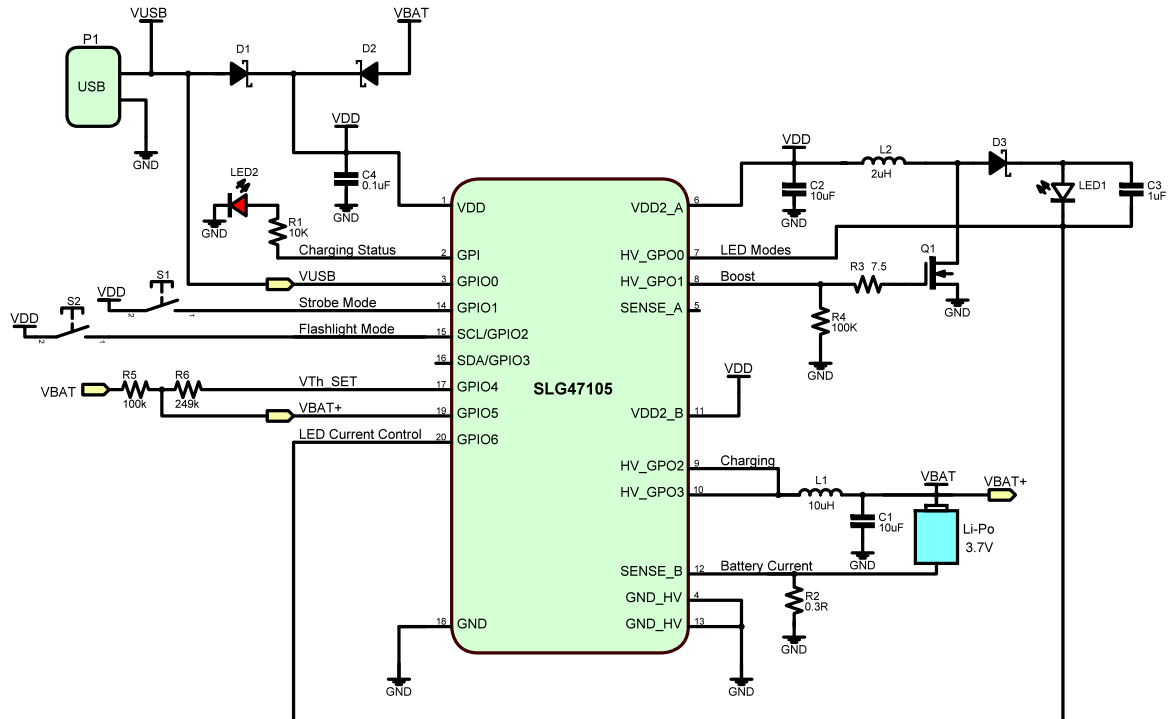


Figure 2: Full Circuit Schematic

As can be seen in [Figure 1](#), the LED Flashlight contains two modes – Flashlight Mode and Strobe Mode. These Modes are selected by two push buttons S1 and S2.

The circuit is powered by a Li-ion battery, so the VDD is between 3.0 V and 4.2 V. The LED intensity depends on voltage VDD, so the DC-DC Boost Converter is added to provide the constant necessary current to the LED.

5. GreenPAK Design

The GreenPAK Design consists of two parts LED Control and CCCV Battery Charger.

5.1 LED Control

The LED Control part is shown in [Figure 3](#).

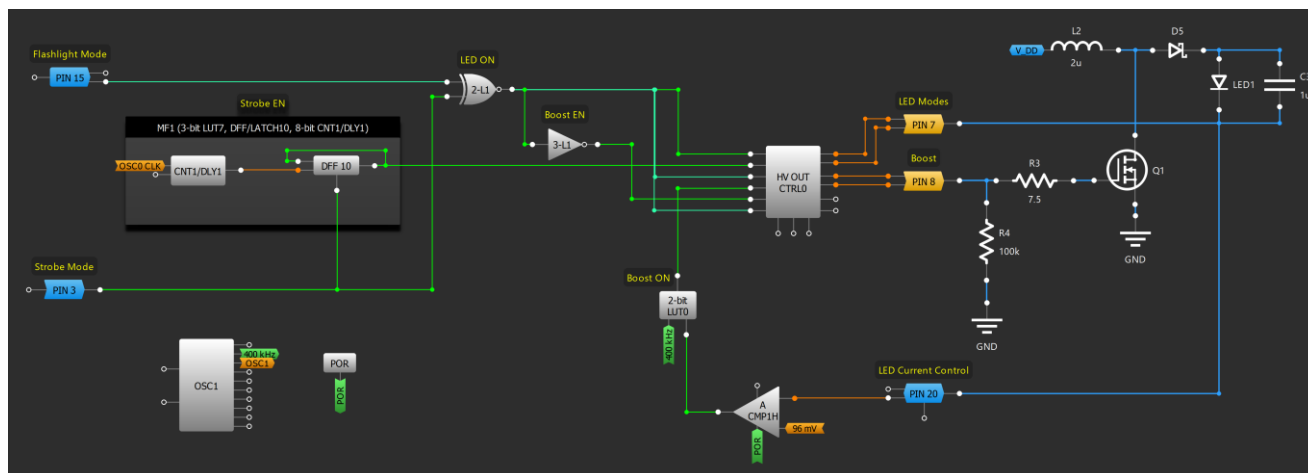


Figure 3: LED Control GreenPAK Design

The 400 kHz signal with a 50% duty cycle is created by OSC1 and goes to the 2-bit LUT0, which controls the Booster circuit through the HV PIN 8. 2-bit LUT1 selects the needed mode, then 3-bit LUT1 enables the Boost circuit (OE1). When the maximum LED current of 700 mA is reached ($V_{ref} = 96 \text{ mV}$, PIN7 Rsense $\sim 150 \text{ m}\Omega$), the ACMP1H sets the LUT0 to 0 and pulls down the HV PIN 8 keeping the current through the LED at the same level. It should be noted, that the external MOSFET must be selected with the lowest possible gate threshold voltage and high enough current. For example IRL3303. The results of Boost can be found in [Figure 4](#) and [Figure 5](#). The HV PIN 8 is represented in blue and the ACMP1H is in green.

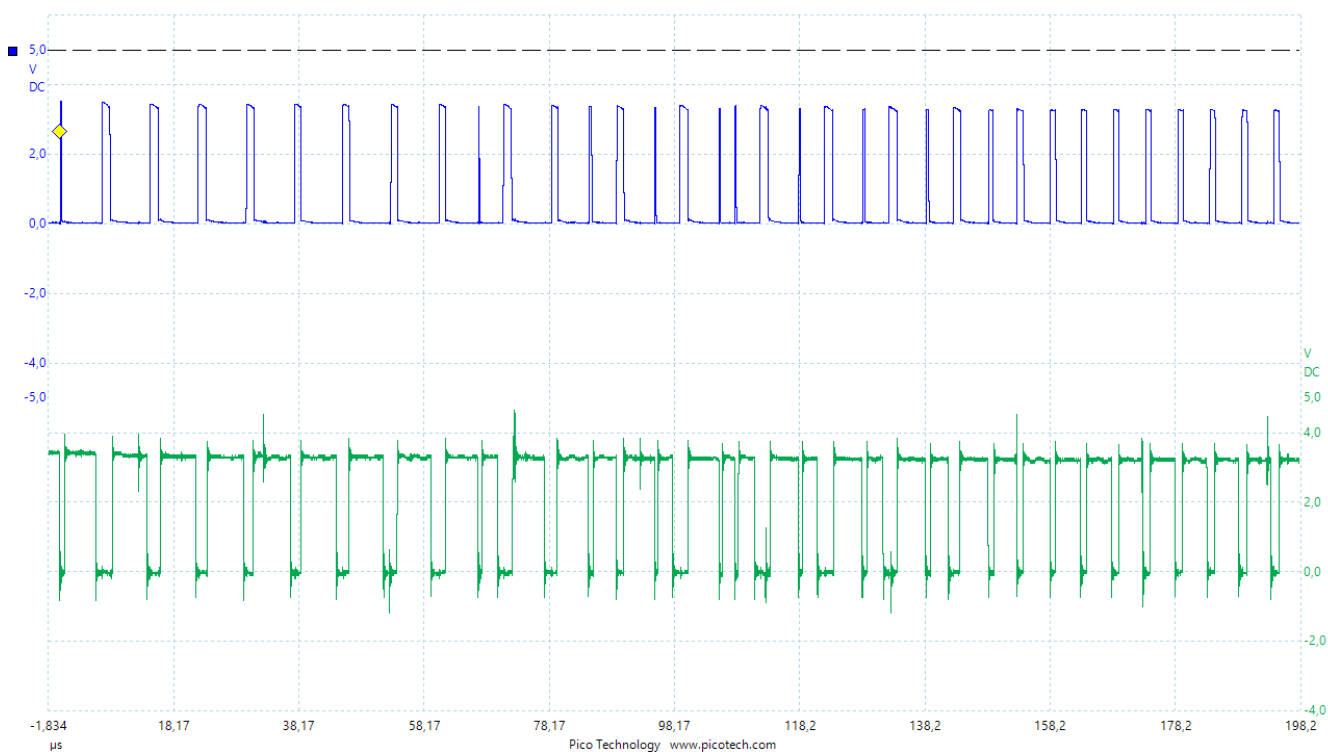


Figure 4: Boost Operation - 3.2 V

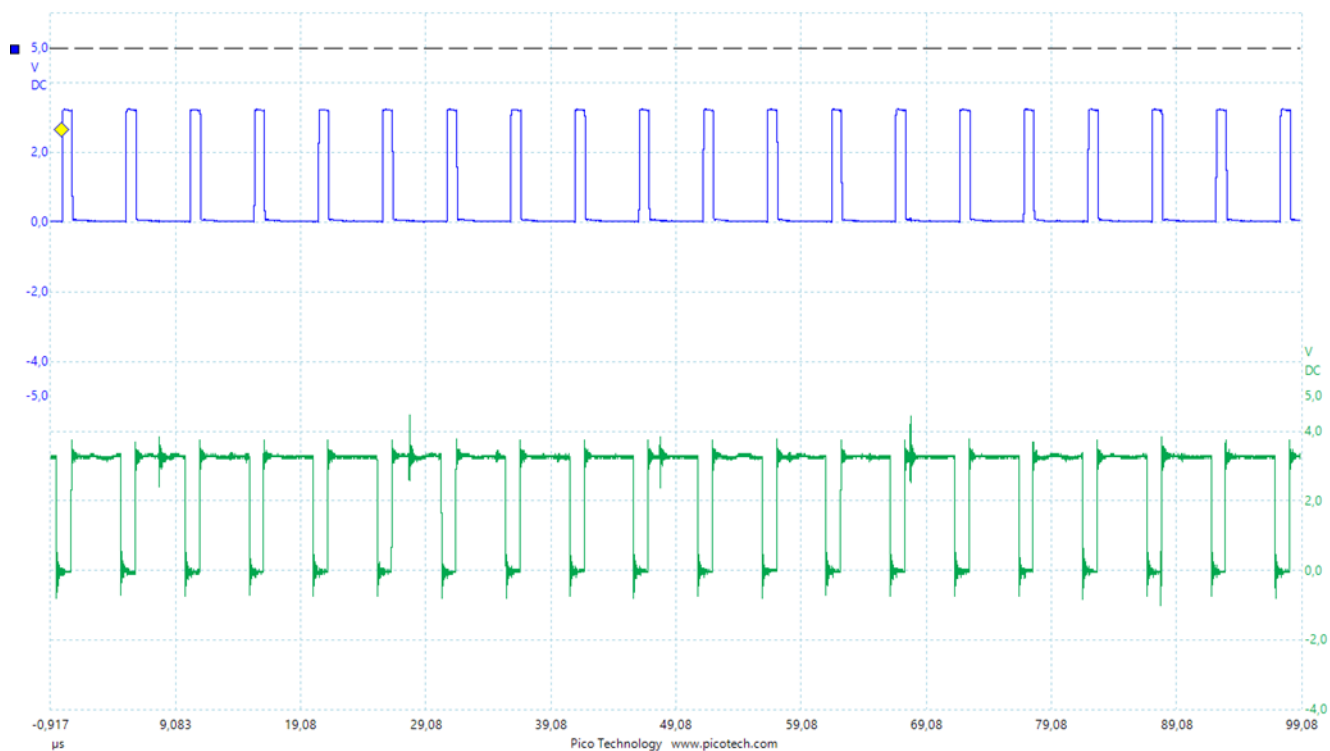


Figure 5: Boost Operation - 3.4 V

The necessary LED mode is selected by 2-bit LUT1 and MF1 (DFF10). These signals go to HV PIN 7 of the HV OUT CTRL0 which is configured as a Half-Bridge and acts as a switch for the LED. So, the LED is ON when PIN 7 is LOW and vice versa. Also, the internal low-side MOSFET (PIN 7) is used as a current sensor. Its RDS On is about 150 mOhm which is perfect for our purpose.

Strobe Mode

In the LED strobe light mode, the 3 W LED is connected to PIN 7 of HV OUT CTRL0 with an input of 11.65 Hz. The resulting LED signal is shown in [Figure 6](#).

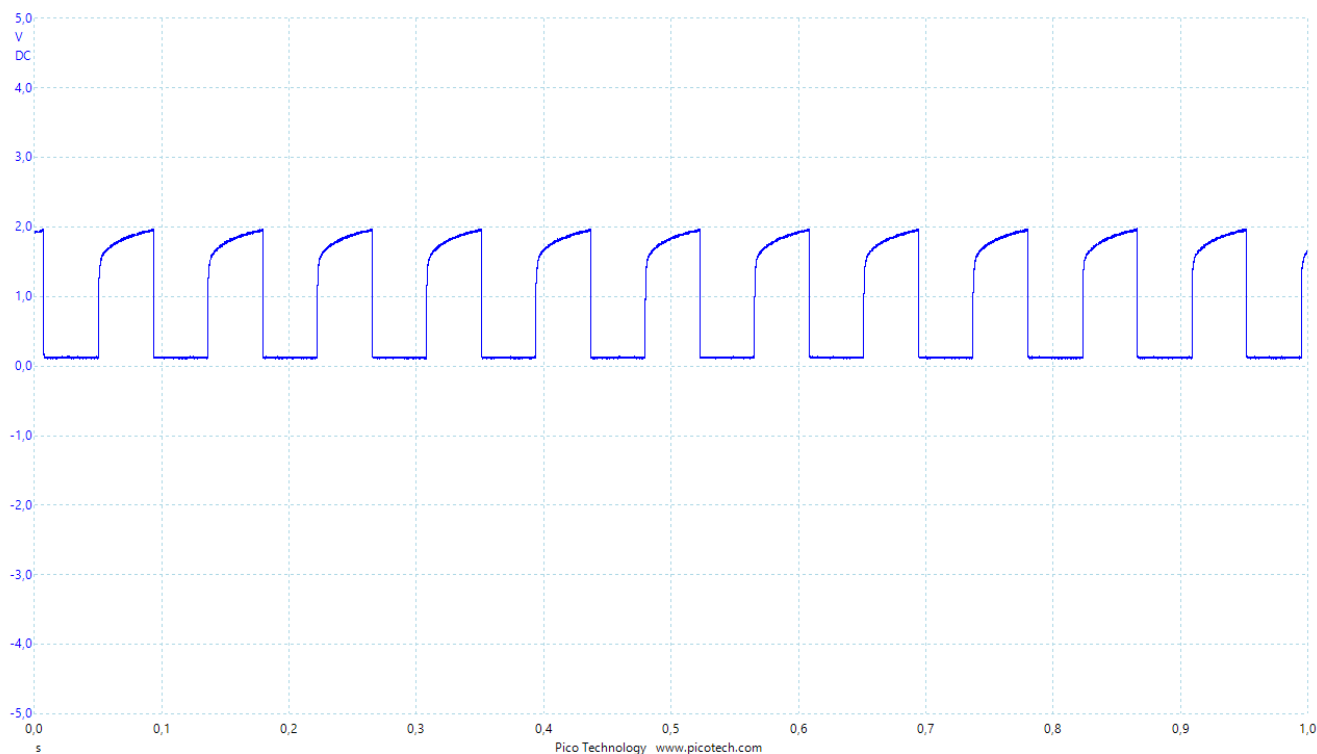


Figure 6: LED Strobe

Flashlight Mode

In the Flashlight Mode, the DFF10 sets the Enable signal OE0 of the HV OUT CNTR0 to HIGH, and the 2-bit LUT1 set the IN0 to LOW, so the output of PIN 7 is continuously LOW, and the LED is continuously ON.

5.2 CCCV Battery Charger

The CCCV Battery Charger GreenPAK Design is shown in Figure 7. To get more information please see [6] .

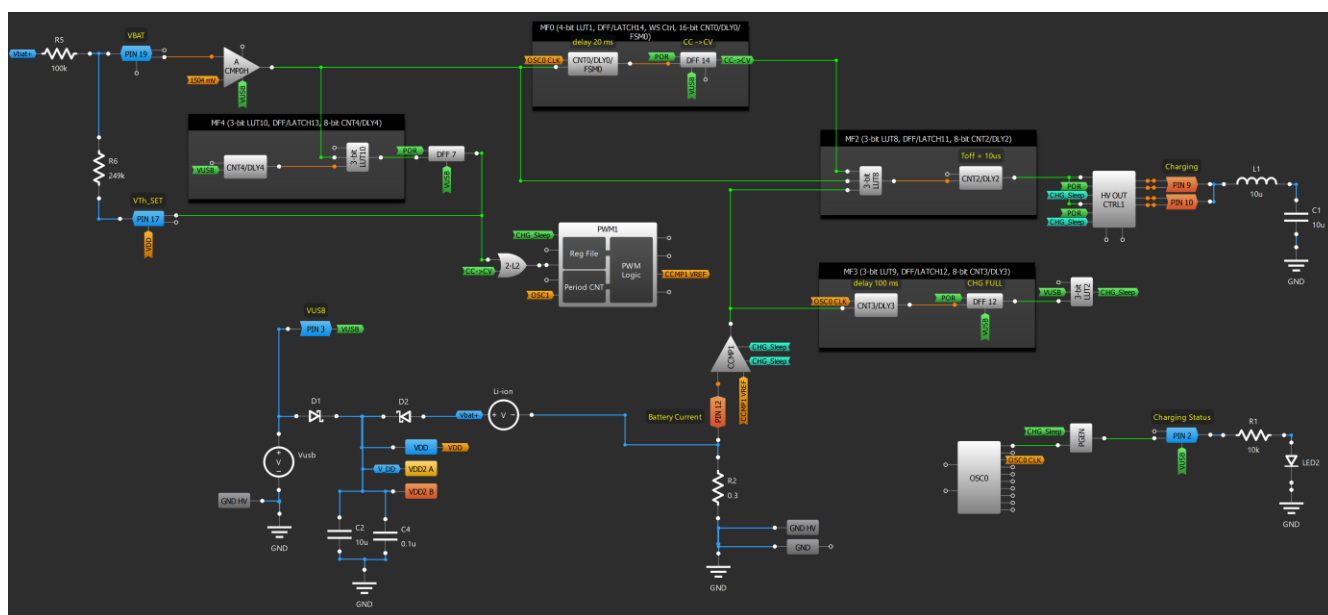


Figure 7: CCCV Battery Charger GreenPAK Design

If the Vusb is connected, PIN3 detects it and powers ON the ACMP0H. The ACMP0H checks the Vbat voltage. DFF7's output is HIGH, so no voltage divider is connected to PIN19. If Vbat is lower than 3 V the **Pre-charging**

stage starts. PWM1 sets the current and CCMP1 controls it (IN+ Source with x8 gain of the CCMP1). In this case, the Up/Down input of the PWM1 macrocell is LOW, which means that we start charging from Vref = 160 mV for CCMP1 Vref (Figure 8). As a result, the CCMP1 maintains the 67 mA current:

$$I_{bat} = \frac{V_{ref}}{\text{Gain} \cdot R_{sense}}$$

As soon as the ACMP0H output is HIGH (the Vbat is higher than 3.0 V), the DFF7 output goes to LOW and the voltage divider is connected to PIN19. The **Constant Current** phase starts. In this case, the ACMP0H makes a comparison for 4.2 V (not 3.0 V as in 1st case). The Up/Down input of the PWM1 is HIGH, so the CCMP1 Vref is 960 mV. The resulting current is ~ 400 mA. Note that these current limits can be changed by changing the Vref value in the Reg File or by changing the resistor connected to the PIN 12 (Sense B).

This CC phase continues until the battery voltage reaches 4.2 V (ACMP0H output is HIGH). Then the Constant Current stops and the **Constant Voltage** phase starts. The Up/Down input of the PWM1 is LOW, so the CCMP1 Vref is 160 mV. In this case, the ACMP0H controls the constant voltage of 4.2 V, and the CCMP1 just checks and keeps the current decreasing and lower than the battery full current (I_{BF}) of 67 mA until the battery is fully charged. When the battery is fully charged, the charging process stops, and all corresponding blocks are in Sleep Mode (CHG_Sleep is HIGH).

Reg File Data: [\[2\]](#)

Byte #	Value	Duty Cycle	Vref
0	29	11.37 %	960 mV
1	4	1.57 %	160 mV
2	4	1.57 %	160 mV
3	4	1.57 %	160 mV
4	4	1.57 %	160 mV
5	4	1.57 %	160 mV
6	4	1.57 %	160 mV
7	4	1.57 %	160 mV

Figure 8: CCMP1 Vref Reg File Data

6. Conclusion

This application note describes how to configure the HVPAK to create a Rechargeable LED Flashlight. The device has two modes - Flashlight and Strobe Light. The results prove that the circuit works as expected, and the HVPAK is capable of acting as the control module for the powerful LED and 3.7 V Li-ion Battery charger at the same time.

The HVPAK's internal resources, including the HV, oscillators, logic, and GPIOs are easy to configure to implement the desired functionality for this design.

7. Revision History

Revision	Date	Description
1.00	August 3, 2023	Initial release.