Toy Car with Push-to-Start / Hold-to-Stop Functionality SLG47105

This application note describes how to implement a Toy Car with Push-to-Start / Hold-to-Stop functionality using the Renesas HVPAK SLG47105. The device is powered by a 3.7 V Li-ion battery that is charged by a Renesas external charger ISL6294. The device also provides a constant voltage to the brushed DC motor.

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

Contents

Figures

1. Terms and Definitions

DC	Direct Current
DFF	D Flip-Flop
LUT	Look-up Table
OSC	Oscillator

2. References

For related documents and software, please visit:

HVPAK: High Voltage Programmable Mixed-Signal Matrix | Renesas

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-365 Toy Car with Push-to-Start / Hold-to-Stop Functionality.hvp, 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

3. Introduction

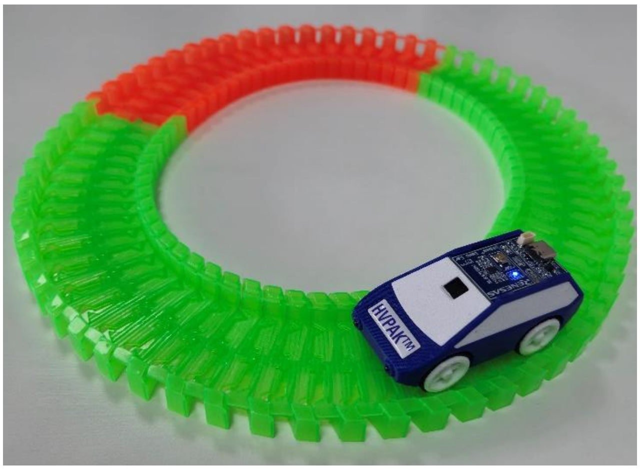

Figure 1. HVPAK Demo Car

The HVPAK Demo Car is small in size and provides fast and efficient movement on the track, allowing children to enjoy high-speed races and exciting adventures (Figure 1).

This application note shows how to implement the Toy Car with Push-to-Start / Hold-to-Stop control using the Renesas HVPAK SLG47105. The following design also features forward and reverse movement, constant voltage on the motor, and LED indicators representing front and rear lights.

Thanks to the Hold-to-Stop functionality, the car automatically turns off when it becomes stationary. So, if the child directs it somewhere and forgets about the toy, the car will switch off and not consume more power once it encounters an obstacle and comes to a stop, thus saving the battery. The Renesas external charger ISL6294 is used to charge the Li-ion battery.

Using only a single SLG47105 and a few extra components it is possible to create a complete device with charging control, motor driving, and other interface features.

4. Operating Principle

The full circuit schematic is presented in Figure 2.

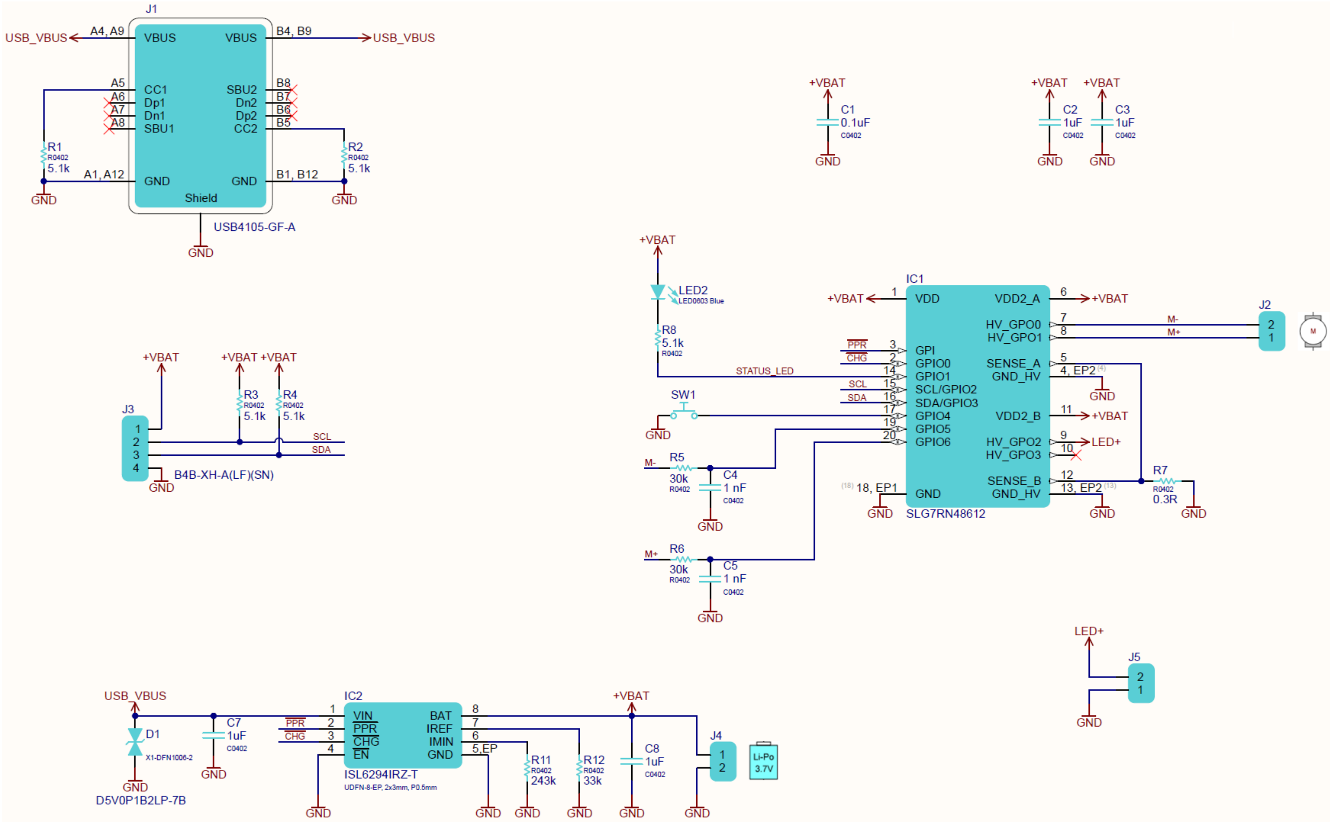

Figure 2. Full Circuit Schematic

A Brushed DC Motor is used for this project. If the car is pushed, the SLG47105 detects it, and the car starts moving forwards or backwards depending on the direction that it was pushed. If the car is stationary, the system powers down after a specified amount of time.

The device is powered by a 3.7 V Li-ion battery. When the USB charger is connected, the SLG47105 detects the charging and stops the motor.

There are also LEDs which indicate the current state of the car.

LED+ (four LEDs) are used as front and rear lights and are ON when the car is moving.

LED2 (BLUE) is a STATUS indicator.

- If the LED is OFF, the SLG47105 is in low-power sleep mode with less than 70 nA current consumption.
- If the LED is constantly ON, this indicates two possible states depending on whether the charger is connected..
  - If the charger is not connected, it means that the car is in a standby mode (waiting for “push-to-start”).
  - If the charger is connected, it means that the battery is fully charged.
- If the LED is breathing, it indicates that the battery is in charging mode.
- If the LED is blinking with a 16 Hz frequency, the car is moving forward.
- If the LED is blinking with a 1 Hz frequency, the car is moving in reverse.

The proposed PCB design is shown in Figure 3.

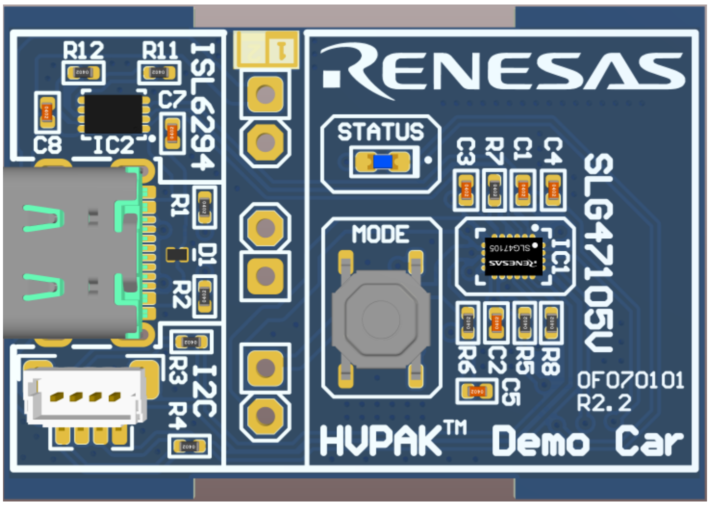

Figure 3. HVPAK Demo Car PCB

5. GreenPAK Design

The GreenPAK Design is shown in Figure 4.

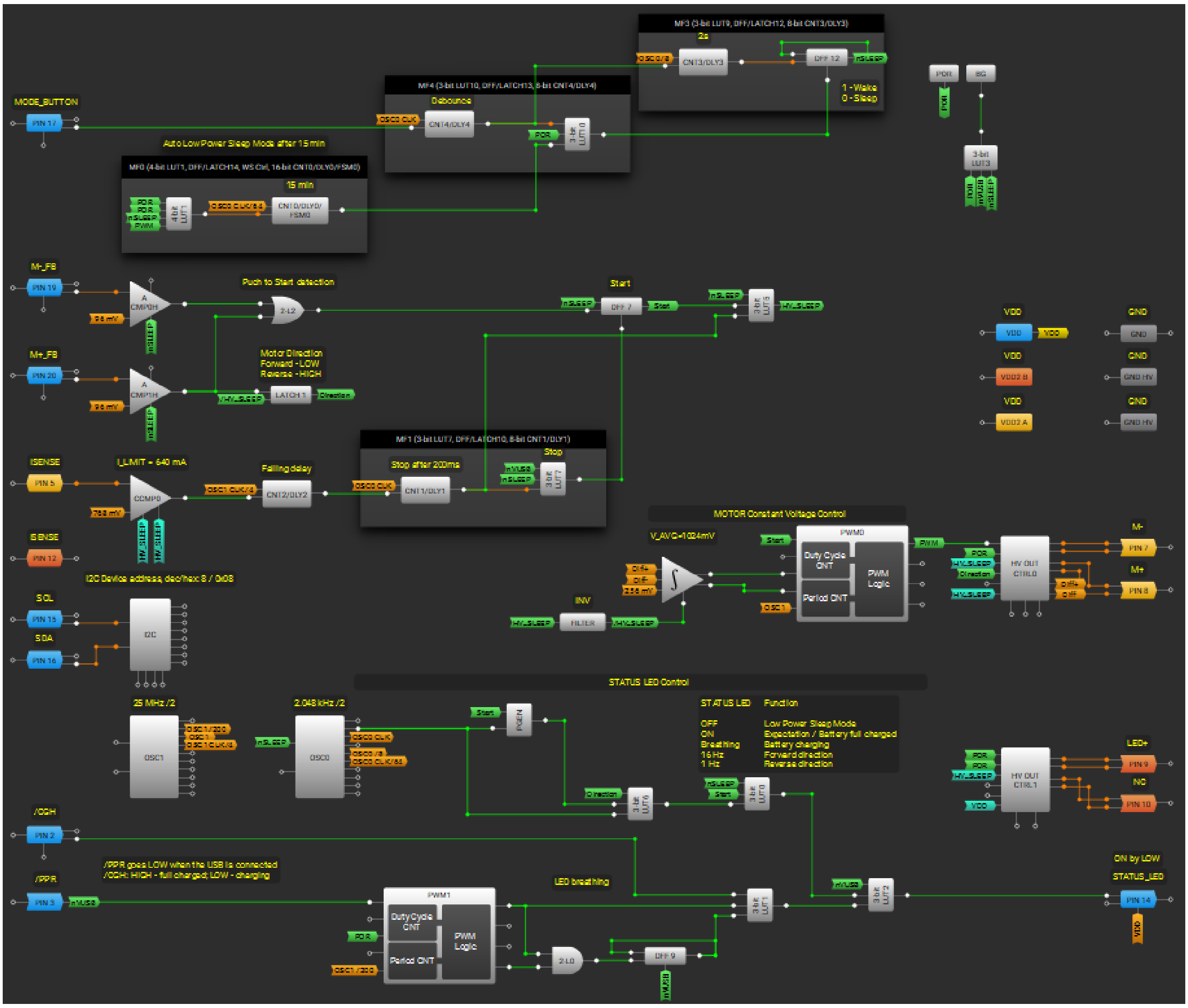

Figure 4. Toy Car GreenPAK Design

The push button is connected to input PIN 17. CNT4/DLY4 is configured as “both” edge detect with a delay of 50 ms forming a button debounce. CNT3/DLY3 is configured as a delayed “falling” edge detect of 2 s which checks if the button has been pressed and held for 2 seconds. If so, its output goes HIGH, clocking DFF 12. The DFF 12 output will change correspondingly from HIGH to LOW and vice versa with each long press of the button. This signal forms the nSLEEP signal. When it is in a LOW state, the system powers down. In addition, MF0 enables the auto low-power sleep mode after 15 minutes without movement. It resets DFF 12 to zero if the button is pressed and no movement occurs after 15 minutes have passed.

The PWM0 block provides a ~50 kHz signal with a PWM depending on the load voltage at the motor. The HV_GPO0_HD and HV_GPO1_HD outputs of the Differential Amplifier with Integrator and Comparator are connected to Diff+ and Diff- of HV OUT CTRL0 (first Full Bridge). This macrocell is used when there is a need to keep a constant voltage at the Full Bridge load. The integrated DC voltage level of 256 mV is applied to the comparator`s negative input and the comparator outputs are used to control the PWM duty cycle. In this case, a closed loop system controls the PWM duty cycle to ensure a constant average output voltage level.

ACMP0H is connected to the M- motor terminal and checks if the car has been pushed in the forward direction. ACMP1H is connected to the M+ motor terminal and checks if the car has been pushed in the reverse direction. When the shaft of the DC Motor rotates in the coil according to the electromagnetic induction law, an electromotive force (EMF) is induced. This signal is detected by one of the ACMPs and the ACMPs’ outputs go to 2-bit LUT2, which detect if the car was pushed. This signal then clocks DFF7, and its output goes HIGH, forming the Start signal for the system.

When the shaft of the DC Motor is stopped, the current increases. CCMP0 is connected to the Sense A resistor (PIN5) and monitors the current. Its output is filtered by CNT2/DLY2 and goes to MF1, which detects whether the current limit has been exceeded. The HIGH signal from 3-bit LUT7 resets DFF7, and the system is powered down.

HV OUT CTRL0 is then powered down with a 200 ms delay (CNT1/DLY1) to give the motor some time to stop (and avoid restarting the system). The nVUSB detect signal is also connected to 3-bit LUT7, so if it is LOW (meaning that the USB is connected), the system is powered down as well. The LED+ LEDs are driven by the Half Bridge of HV CTRL1 and are enabled synchronously along with the motor.

The STATUS LED is activated by a LOW signal on PIN 14. 3-bit LUT2 controls the STATUS LED depending on the mode of the car – moving or charging. If the USB is connected, the nVUSB signal is LOW, and the STATUS LED indicates that charging is in progress.

3-bit LUT1 switches the LED logic depending on the charging state. If the PIN 2 OUT (/CGH) signal is HIGH, the battery is fully charged, and the LED will be constantly ON. If the PIN 2 OUT signal is LOW, the battery is charging, and the LED indicator will light up in a breathing pattern (slow pulsing). PWM1, 2-bit LUT0, and DFF 9 are used to create this breathing effect.

If the USB is not connected, the nVUSB signal is HIGH, and the STATUS LED will instead indicate the status of the car’s movement.

3-bit LUT0 checks if the car is powered ON (nSleep) and determines whether the car should start moving (Start). If the car is turned ON, but no “push-to-start” is detected for the following 15 minutes, the LED will be constantly ON.

If movement is detected, 3-bit LUT6 switches the LED logic depending on the direction. OSC0 forms the 16 Hz frequency for LED blinking in case of forward direction. The PGEN forms the 1 Hz frequency for the LED in case of reverse direction.

6. Device Testing

Figure 5, Figure 6, and Figure 7 show the motor constant voltage control. The higher the V_{DD} voltage, the lower the duty cycle required by the motor to maintain a constant load voltage.

Channel 1 (green / 1st line) – V_{DD}.

Channel 2 (red / 2nd line) – PIN 7 (M-).

Channel 3 (blue / 3rd line) – PIN 8 (M+).

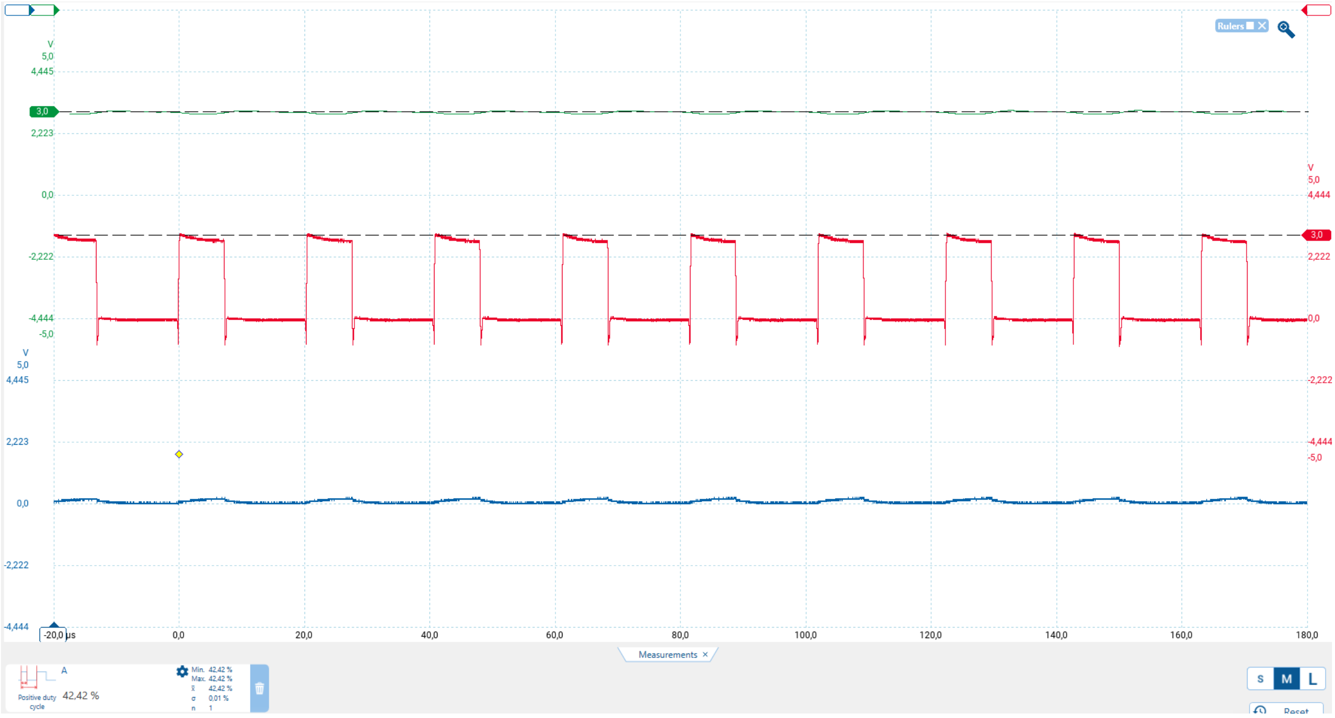

Figure 5. V_{DD} = 3.0 V, duty cycle 42.42%

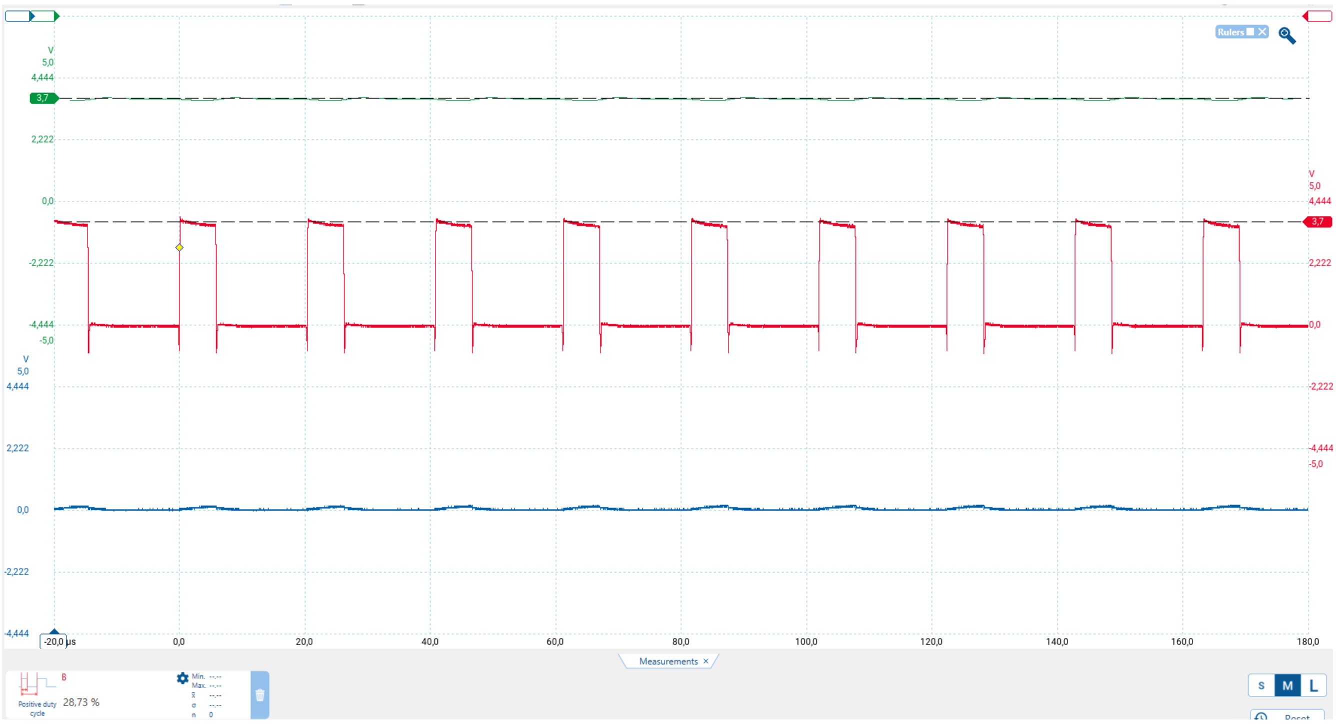

Figure 6. V_{DD} = 3.7 V, duty cycle 28.73%

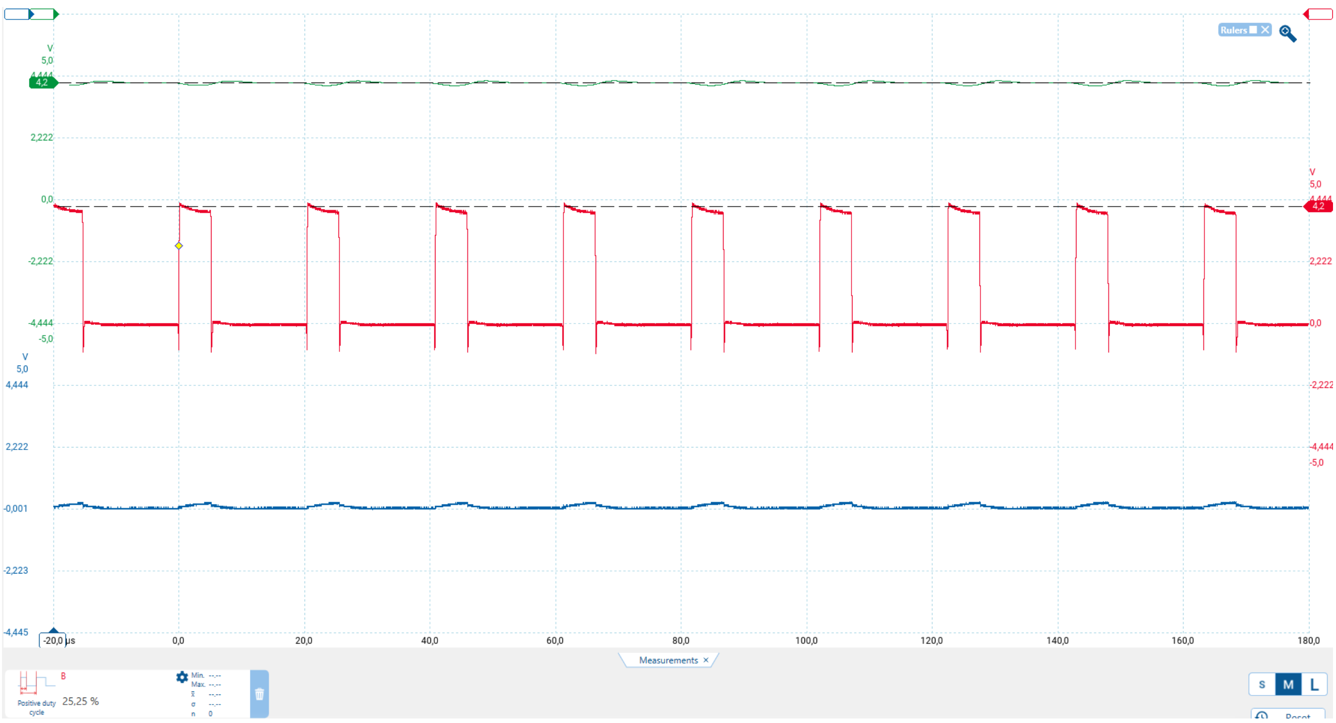

Figure 7. V_{DD} = 4.2 V, duty cycle 25.25%

Figure 8 shows the peak over 96 mV on PIN 20 (M- terminal) during Push-to-Start, which powers on the system. It enables the forward motor direction.

Channel 1 (blue / 1st line) – PIN 8 (M+).

Channel 2 (red / 2nd line) – PIN 7 (M-).

Channel 3 (green / 3rd line) – PIN 20 (ACMP1H IN+).

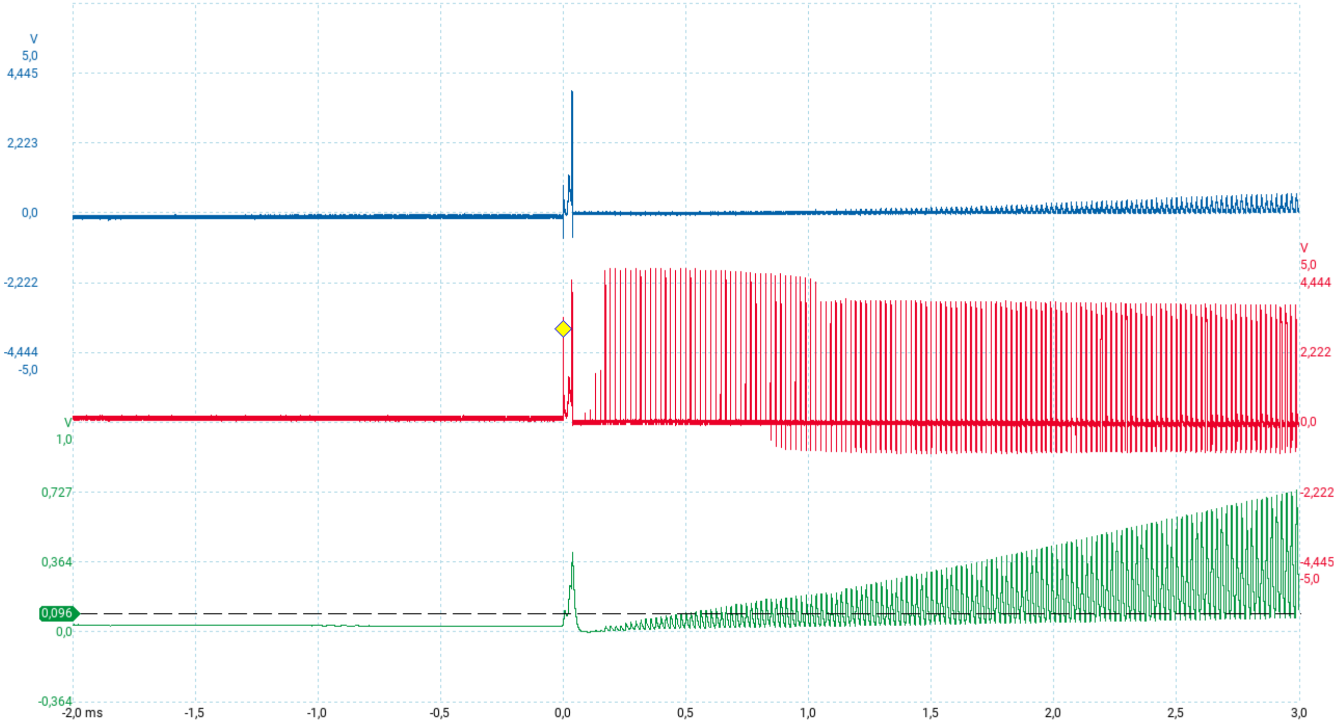

Figure 8. Push-to-Start Forward Direction

Figure 9 shows the peak over 96 mV on PIN 19 (M+ terminal) during Push-to-Start, which powers on the system. It enables the reverse motor direction.

Channel 1 (blue / 1st line) – PIN 8 (M+).

Channel 2 (red / 2nd line) – PIN 7 (M-).

Channel 3 (green / 3rd line) – PIN 19 (ACMP0H IN+).

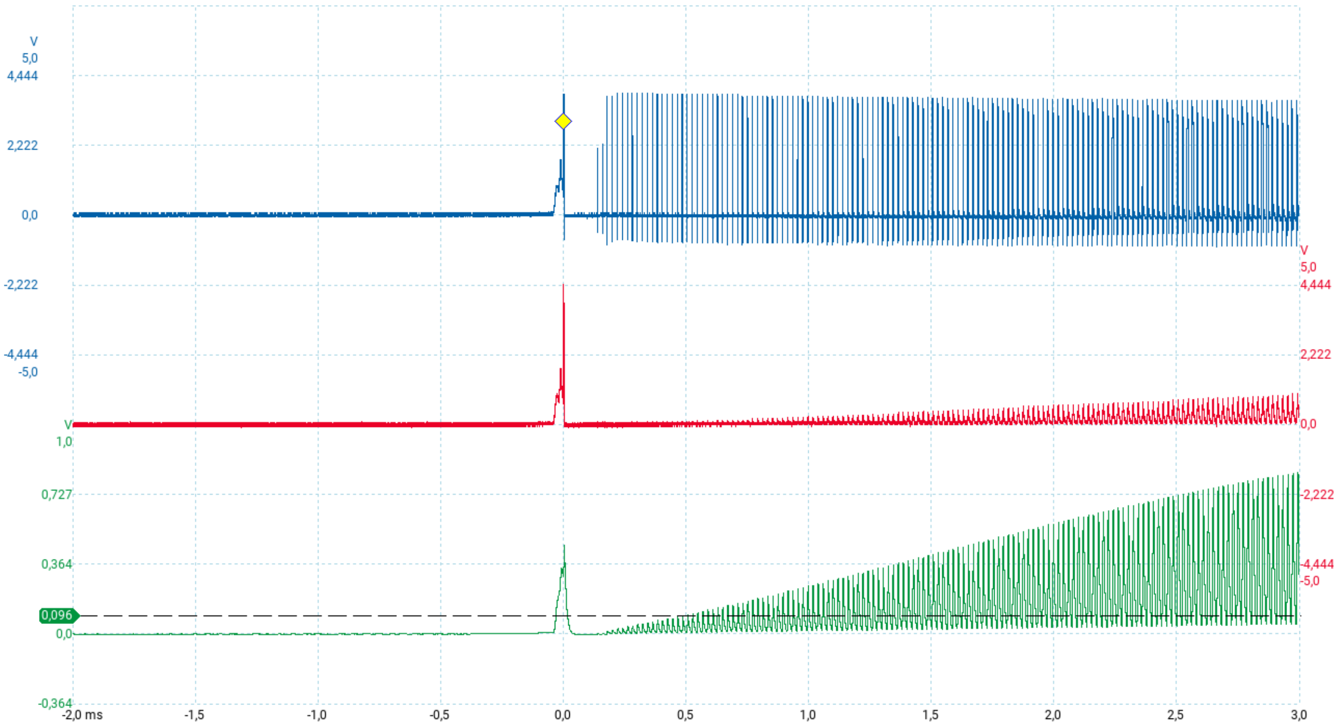

Figure 9. Push-to-Start Reverse Direction

Figure 10 shows the normal system behavior without the hold-to-stop applied. The current on the motor does not exceed the threshold of 640 mA (192 mV on PIN 5), and the system operates in normal mode.

Channel 1 (blue / 1st line) – PIN 8 (M+).

Channel 2 (red / 2nd line) – PIN 7 (M-).

Channel 3 (green / 3rd line) – PIN 5 (CCMP0 IN+).

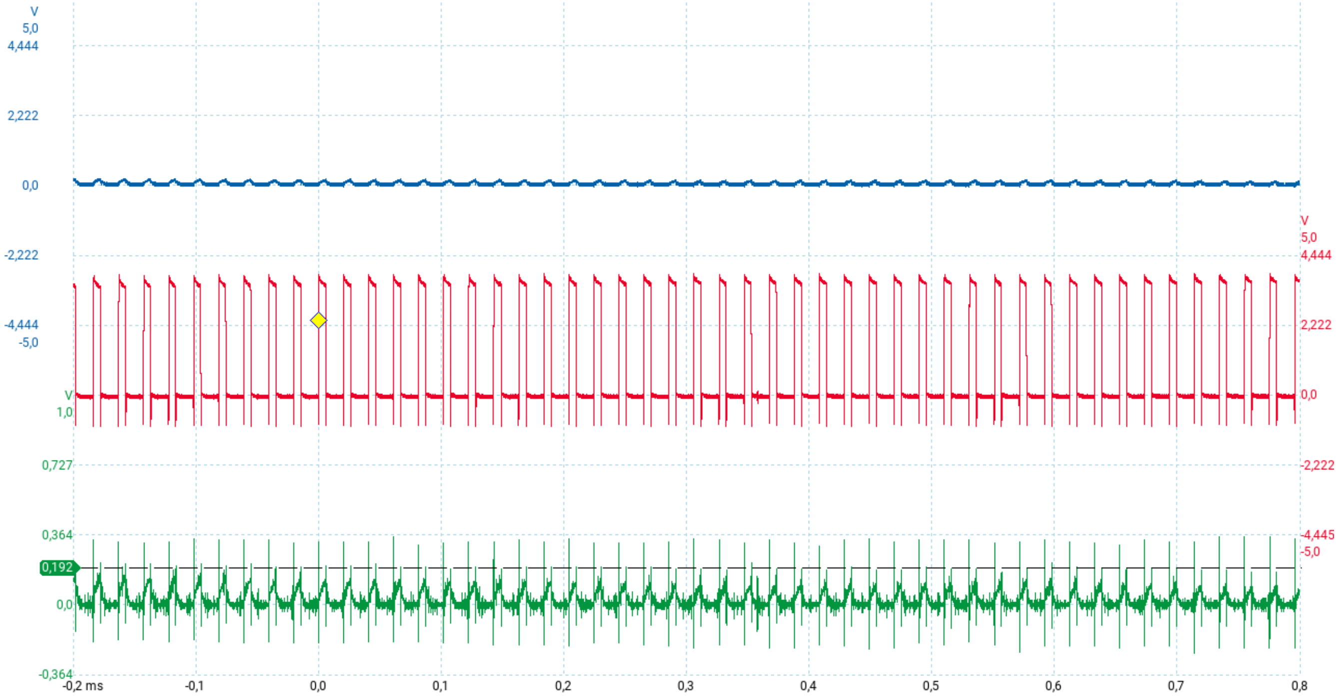

Figure 10. No Hold-to-Stop Operation

Figure 11 and Figure 12 show the Hold-to-Stop operation at the whole trace and zoom in accordingly. As soon as the current on the motor exceeds the threshold of 640 mA (192 mV on PIN 5), the HV outputs operate for another 200 ms, and then the motor stops.

Channel 1 (blue / 1st line) – PIN 8 (M+).

Channel 2 (red / 2nd line) – PIN 7 (M-).

Channel 3 (green / 3rd line) – PIN 5 (CCMP0 IN+).

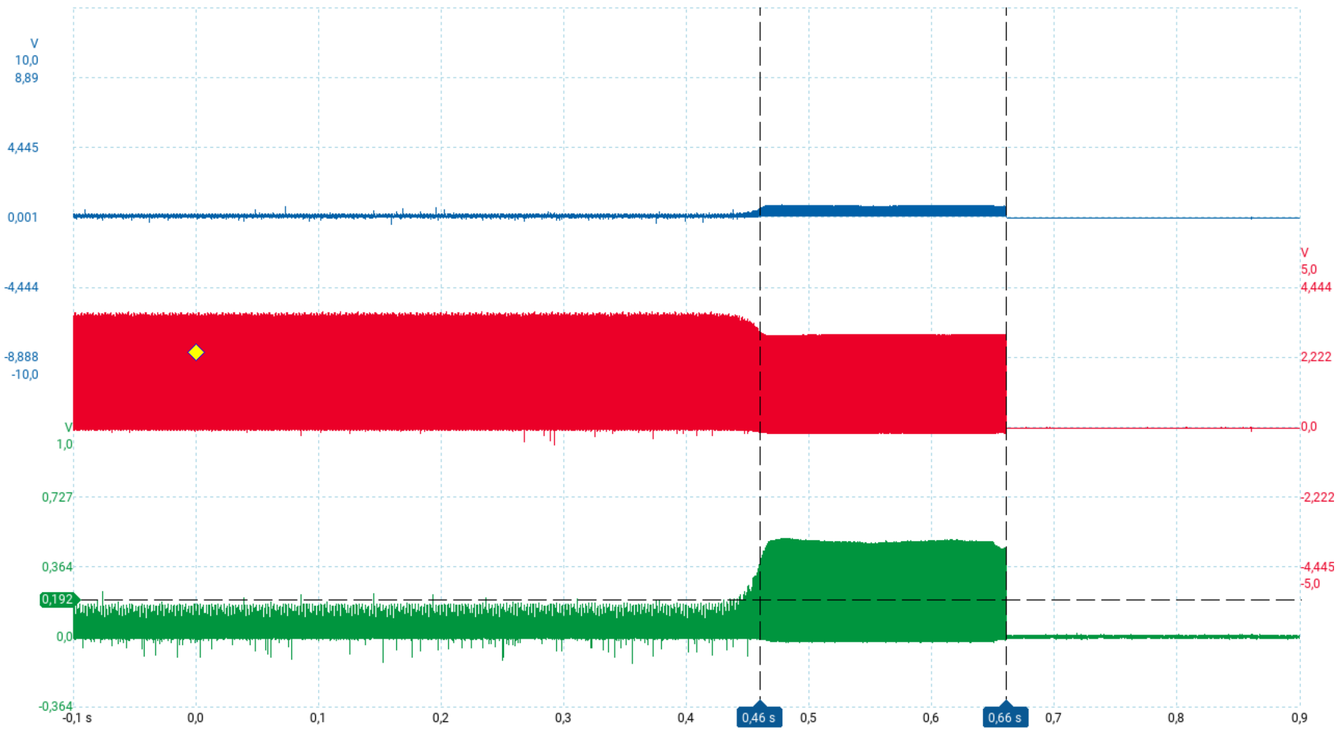

Figure 11. Hold-to-Stop Operation, Whole Trace

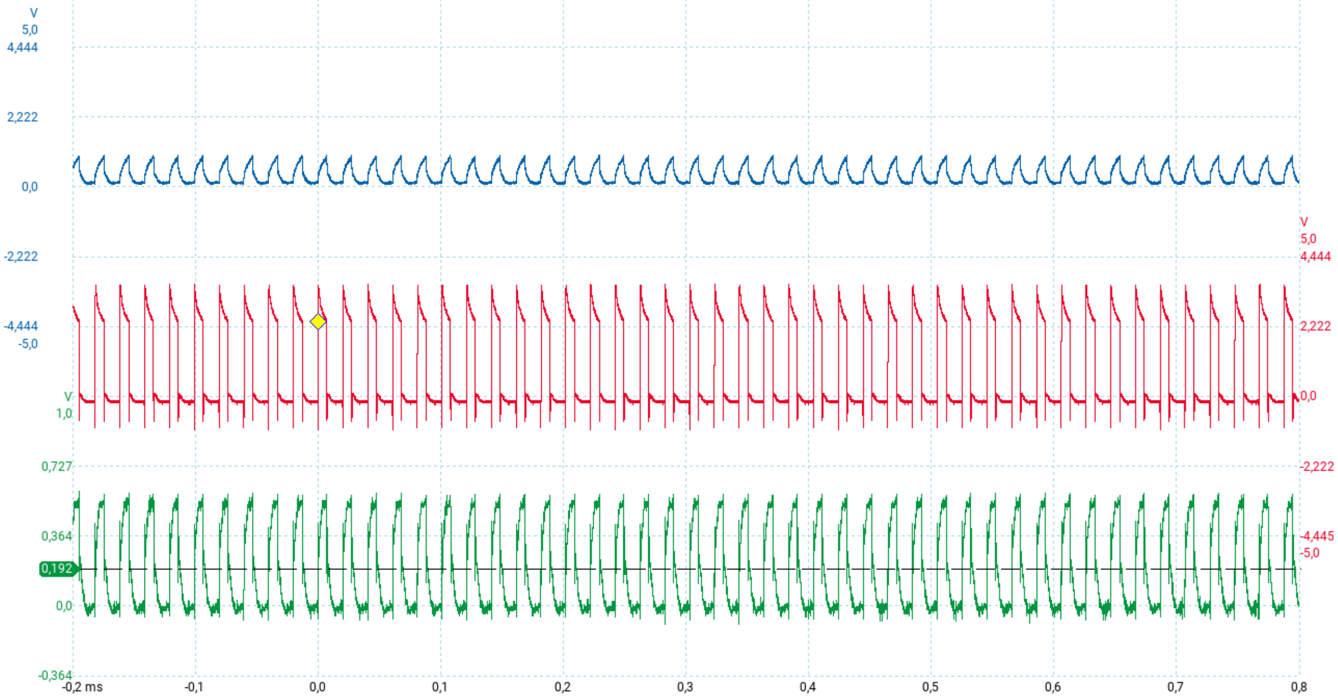

Figure 12. Hold-to-Stop Operation, Zoomed

7. Conclusion

This application note describes how to configure the HVPAK SLG47105 to create a Toy Car with Push-to-Start/Hold-to-Stop functionality. The results show that the circuit works as expected, and the SLG47105 is capable of acting as the control module for the car's Brushed DC Motor and LEDs.

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

8. Revision History

Revision	Date	Description
1.00	June 5, 2025	Initial release

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