Embedded
Code Generation

Tutorial

Trigger Configuration using PLECS STM32 TSP

Tutorial Version 1.0

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Introduction

In this tutorial you will continue to learn how to use STM32 microcontrollers (MCUs) with the PLECS Coder and the STM32 Target Support Package.

Before you begin

- Make sure you are familiar with the basic concepts introduced in the tutorial titled, "Introduction to PLECS STM32 Code Generation." This is an advanced tutorial.
- We are going to continue to work with the STM32 NUCLEO-G474RE board [1].

Exercise 1 Trigger Configuration

In the digital power electronic control loop, time synchronization of signal measurement via the analog-to-digital converter (ADC), control logic execution, and actuation via PWM outputs is critical. In this exercise you will learn how to configure the ADC and control loop interrupts through the ADC trigger and task trigger signals. Refer to the Control Task Execution section of [3] for a detailed explanation.

Task 1.1 PWM Loopback

Your Task:

1. *Open a pre-built PLECS model:* Locate and open the PLECS model `stm32_trigger_pwm_loopback.plecs` from the reference files. You will notice that the start-of-conversion of the ADC is being triggered by the Timer at a frequency of 10e3 Hz and the PWM **Carrier frequency** is set to 0.6e3 Hz, as shown in Fig. 2.
2. *Run an offline simulation:* Vary the value of duty cycle as desired (must be in between 0-1), start the simulation (**Ctrl + T**) and observe the simulation results.
3. *Make the required hardware connections:* Connect the pins PB9 (CN10-5, PWM) to PA1 (CN7-30, Analog In) of an STM32 G474RE MCU using a jumper wire, as shown in Fig. 1.
4. *Flash the STM32 MCU and connect to the External Mode:* From the **Coder Options** window, **Build** the "Controller" subsystem onto the MCU. Once the generated code is running on the target, **Connect** to the External Mode to update the PLECS scope, as explained in the Introduction to PLECS STM32 Code Generation tutorial. Confirm that the PWM waveform is sampled.
5. *Vary the value of duty on the fly:* Since the duty cycle parameter has been added to the list in the **Parameter Inlining** tab, its value can be varied in real time on the fly, while connected to External Mode. Modify the duty cycle and observe the real-time simulation results.
6. *Disconnect from External Mode and modify the PLECS model:* Next, **Disconnect** from the External Mode. From the PWM block parameters window, increase the **Carrier frequency** to 6e3.
7. *Repeat steps 2-6:* Now experience the sampling artifacts in offline and real-time simulations for a switching frequency of 6e3 Hz.
8. *Change the Analog In Trigger source:* Next, switch the ADC trigger to be generated by the PWM block instead of the Timer, as shown in Fig. 3. Observe the offline simulation results. Then re-build the "Controller" subsystem onto the STM32 MCU, **Connect** to the External Mode, modify the duty cycle on the fly and observe the real-time simulation results.

What do you observe at the end of Task 1.1?

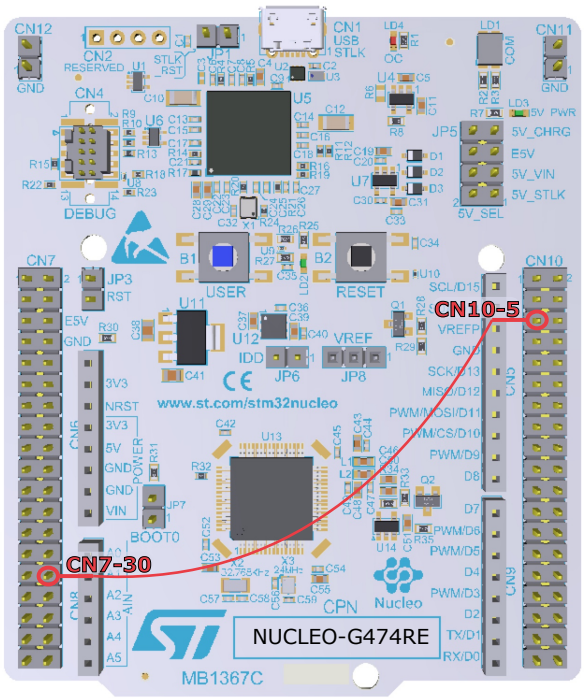

Figure 1: Pin configuration of the PWM to ADC Loopback

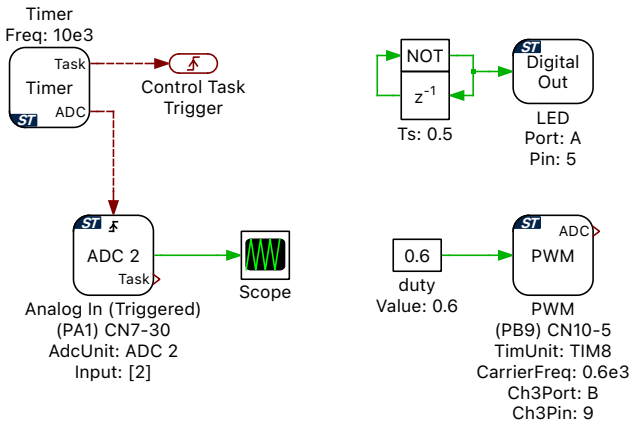

Figure 2: ADC start-of-conversion triggered by Timer

You will observe that based on whether the **Trigger event** from the **Trigger** tab of the PWM block parameters is set to `Overflow` or `Underflow`, the result will always read either 0 or 3.3, irrespective of the duty cycle (for values in between 0-1).

At this stage, your model should be the same as the reference `stm32_trigger_1.plecs`.

Task 1.2 Optional: Filtered PWM Loopback

Optionally, you can add an RC filter in between the loopback from the PWM output to the ADC input, as shown in Fig. 4.

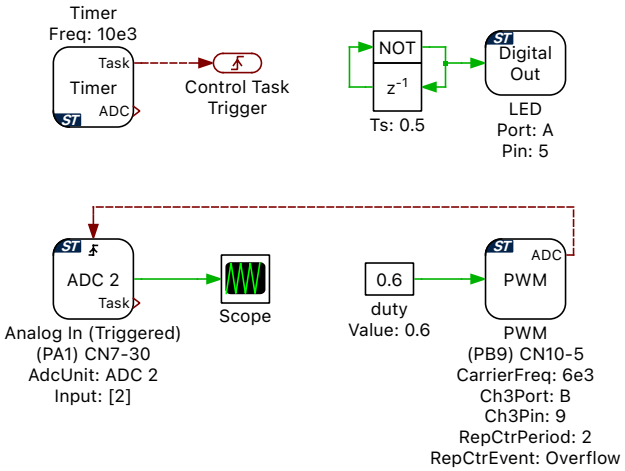

Figure 3: ADC start-of-conversion triggered by PWM

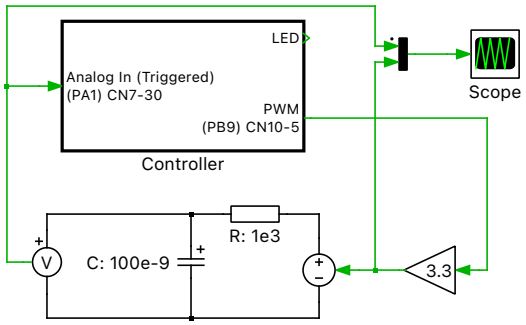

Figure 4: Install an RC filter in between the loopback from PWM output to ADC input

Your Task: Locate and open the PLECS model `stm32_trigger_filtered_pwm_loopback.plecs` from the reference files and repeat all the steps from Task 1.1 with the exception of the hardware connections that will change. This time, use an RC cable instead of using a jumper wire to make a loopback between the PWM and the ADC, as shown in Fig. 5. Connect a wire from the free end of the resistor to PB9 (CN10-5, PWM), another from the resistor-capacitor junction to PA1 (CN7-30, Analog In), and the third from the free end of the capacitor to GND.

How are the results at the end of Task 1.2 different from Task 1.1?

At the end of Task 1.2, you will notice that the sampling of the filtered PWM signal occurs at the average of the PWM waveform, and the average value now increases and decreases with the duty cycle accordingly, as shown in Fig. 6.

At the end of this exercise, your model should be the same as the reference `stm32_trigger_2.plecs`.

References

[1] STMicroelectronics, NUCLEO-G474RE: https://www.st.com/en/evaluation-tools/nucleo-g474re.html

[2] *RT Box User Manual*, Plexim GmbH, Online: https://www.plexim.com/sites/default/files/rtboxmanual.pdf

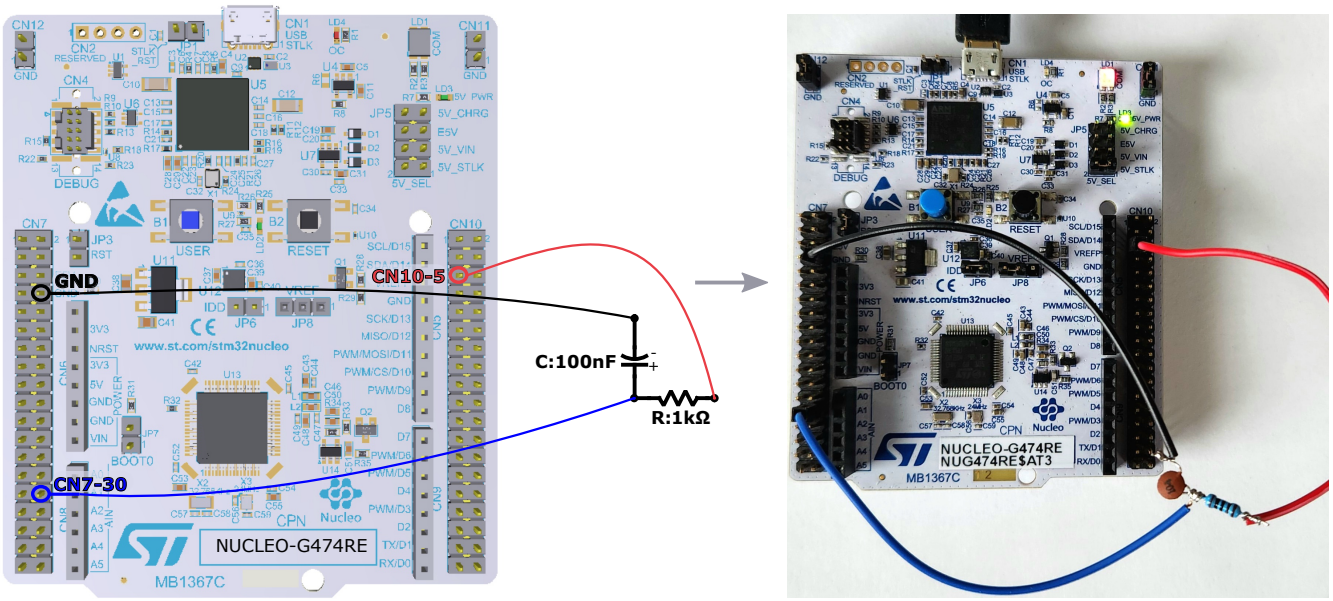

Figure 5: Pin configuration of the PWM to ADC Loopback with an RC filter

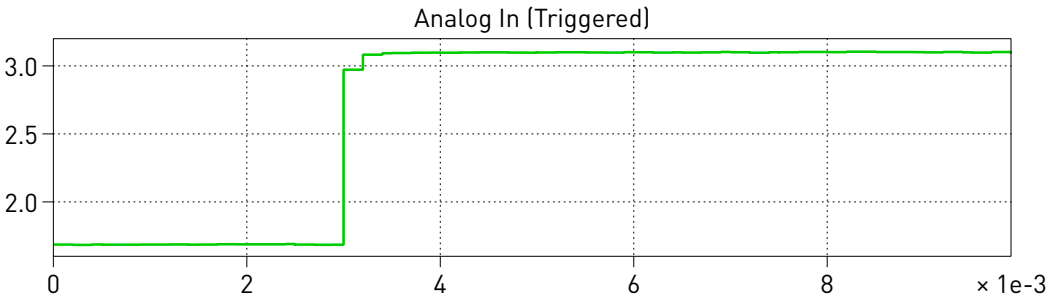

Figure 6: Analog In measurements of the filtered PWM loopback model in real time when duty is varied from 0.4 to 0.9

[3] STM32 Target Support User Manual: https://plexim.com/sites/default/files/stm32manual.pdf

[4] STM32G4 Nucleo-64 boards (MB1367) User Manual: https://www.st.com/resource/en/user_manual/um2505-stm32g4-nucleo64-boards-mb1367-stmicroelectronics.pdf

Revision History:

Tutorial Version 1.0	First release

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