

**Embedded  
Code Generation**  
*DEMO MODEL*

## Simple Model

**A simple model to get started with the TI C2000 TSP**

Last updated in C2000 TSP 1.9.1

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# 1 Overview

This demo features a simple model that shows how to use Texas Instruments (TI) C2000 microcontrollers (MCUs) with the PLECS Coder and the TI C2000 Target Support Package.

The model is split into eight distinct subsystems called “28069”, “280049”, “28377S”, “28379D”, “280039”, “28P650DK9”, “28P550SJ9”, and “29H850TU”. Each subsystem can be independently deployed to the corresponding TI C2000 LaunchPad target hardware. The following sections provide a brief description of the model and instructions on how to simulate it.

## 2 Model

The top level schematic contains eight separate subsystems, as shown in Fig. 1. The subsystem labeled “28069” is configured for the TI 28069 LaunchPad [1], the subsystem labeled “280049” is configured for the TI 280049C LaunchPad [2], the subsystem labeled “28377S” is configured for the TI 28377S LaunchPad [3], the subsystem labeled “28379D” is configured for the TI 28379D LaunchPad [4], the subsystem labeled “280039” is configured for the TI 280039C LaunchPad [5], the subsystem labeled “28P650DK9” is configured for the TI 28P650DK9 LaunchPad [6], the subsystem labeled “28P550SJ9” is configured for the TI 28P550SJ9 LaunchPad [7], and lastly the subsystem labeled “29H850TU” is configured for the TI 29H850TU LaunchPad [8].

Each subsystem is enabled for code generation, as indicated by the thick outer border of the subsystem blocks. This step is necessary to generate the model code for a subsystem using the PLECS Coder. This setting is configured by selecting the subsystem, opening **Edit + Subsystem + Execution settings...** menu, and then selecting the **Enable code generation** option.

The generated code runs at a base sample time on the MCU. This sample time also defines how the continuous states of the model equations are discretized. The sample time is configured by the **Discretization step size** setting in the **Coder + Coder Settings + Scheduling** window. In this model, the discretization step size of each of the subsystems is set to 100  $\mu$ s.

Each of the subsystems includes a simple model to blink an LED on the LaunchPad, using a Digital Out block of the TI C2000 Target component library, and to generate two sinusoidal waveforms that are measured with a PLECS Scope, as shown in Fig. 2.

The MCU’s pulse-width modulator (PWM) peripheral is configured by the PWM block, as shown in Fig. 3. Duty cycle is provided as an input to this block. The **Carrier type** and **Carrier frequency** parameters can be configured from the **Main** tab of the PWM block parameters window. Also, the PWM block is configured to generate a Single output on channel A from the **Output** tab of the parameters window.

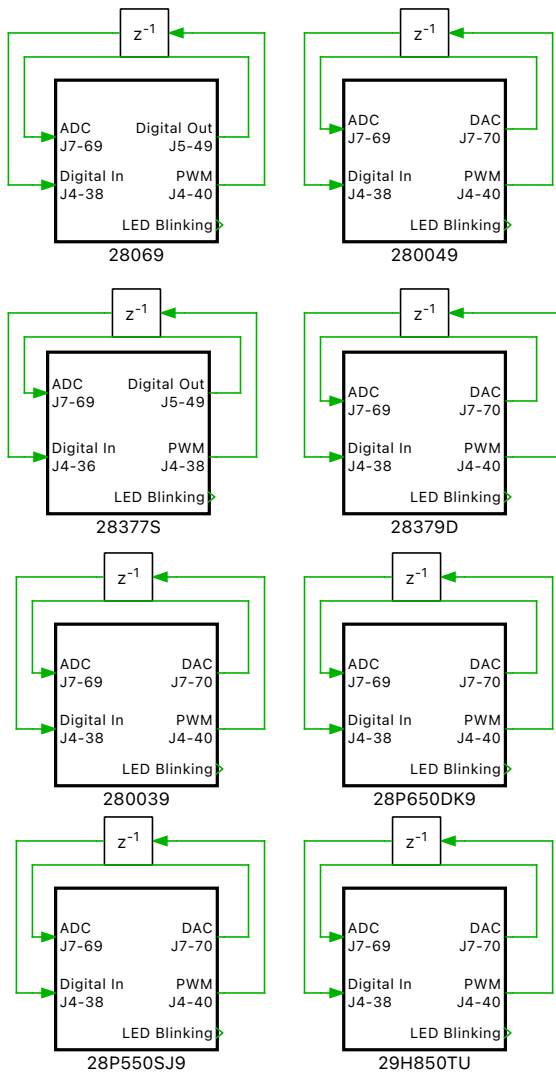
By externally connecting the PWM output to a digital input via a jumper wire, the generated PWM signals can then be sensed and used in the model environment. The Digital In block is used for this purpose.

Analog signals are sensed by configuring the analog-to-digital (ADC) peripheral of the MCU. In a similar fashion, analog signals are generated by using the digital-to-analog (DAC) peripheral device, which are available on the 280049, 28379D, 28P550SJ9, 28P650DK9, and 280039 LaunchPad devices.

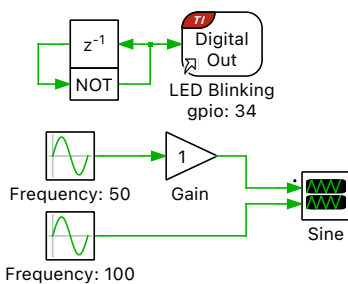
In this model a DAC block is used to generate an analog signal and an ADC block is then used to sense the signal, using an external jumper wire to connect appropriate pins. Optionally, scaling and offset factors can be configured for each channel via the parameter window of the ADC and DAC blocks.

Since 28069 and 28377S LaunchPads do not have the DAC peripheral, a pulsating digital signal is fed into the ADC instead of an analog signal, as shown in Fig. 4.

Simple model with eight distinct subsystems  
Each subsystem can be independently deployed to the  
corresponding TI C2000 LaunchPad target



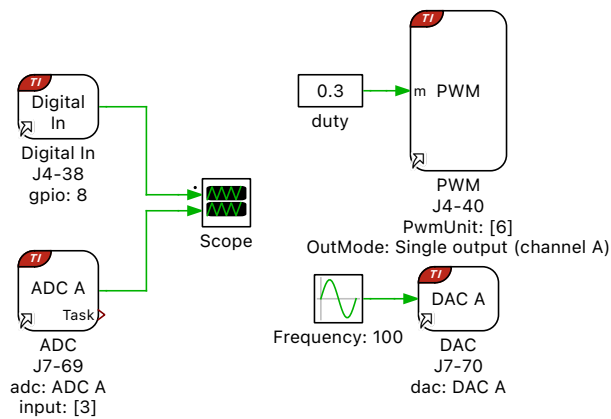
**Figure 1: Top level schematic of the model with eight subsystems**



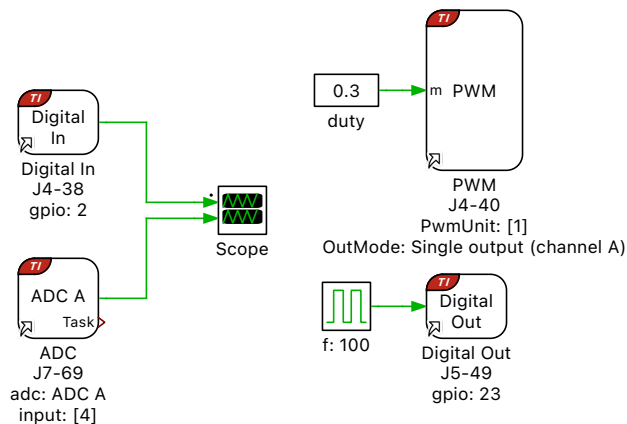
**Figure 2: Circuit to blink an LED and generate sine waveforms**

### 3 Simulation

Each subsystem can be directly converted into target specific code for the corresponding TI LaunchPad hardware.



**Figure 3: Circuit to generate PWM and analog waveforms on 280049, 28379D, 280039, 28P650DK9, 28P550SJ9, and 29H850TU**



**Figure 4: DAC block is replaced with a Digital Out block on 28069 and 28377S**

**Note** Before proceeding, ensure the DIP switch position and jumper configuration on the LaunchPad device are correctly configured. Guidance for each LaunchPad device is provided in the “Tips for Programming C2000 Development Kits” section of the TI C2000 Target Support User Manual [9]

## Flash the MCU

Follow the instructions below to upload the subsystems to a TI MCU.

- Connect the desired MCU to the host computer through a USB cable.
- From the **System** tab of the **Coder + Coder options...** window, select the MCU of interest.
- Next, from the **Target** tab, select the appropriate target from the dropdown menu. Then under the **General** sub-tab, select the desired **Build type**.
- Then, to Build and program the MCU directly from PLECS, choose either Run from Flash or Run from RAM as the **Build configuration**, then select LaunchPad as the **Board** type, and click **Build**.

If programmed correctly, the LED on the LaunchPad board should blink.

For advanced users who are familiar with Code Composer Studio (CCS), there is an option to Generate code into CCS project. Included with the TI C2000 Target Support package is a folder titled

projects. Within the folder there are ZIP archives containing pre-built CCS projects for each MCU. Extract the ZIP archive, locate the `cg` folder within the CCS project, enter its path into the **CCS project directory** field and click **Build**. The code of the desired MCU subsystem will be automatically generated. Then, proceed to build and debug the project as a normal CCS project. Refer to “Quick Start” section of the TI C2000 Target Support User Manual [9] for detailed step-by-step instructions.


## Connect the hardware

Next, connect the pin numbers listed below using jumper wires for the desired MCU.

- **28069** Connect J4-40 to J4-38; and J7-49 to J7-69.
- **280049** Connect J4-40 to J4-38; and J7-70 to J7-69.
- **28377S** Connect J4-38 to J4-36; and J7-49 to J7-69.
- **28379D** Connect J4-40 to J4-38; and J7-70 to J7-69.
- **280039** Connect J4-40 to J4-38; and J7-70 to J7-69.
- **28P650DK9** Connect J4-40 to J4-38; and J7-70 to J7-69.
- **28P550SJ9** Connect J4-40 to J4-38; and J7-70 to J7-69.
- **29H850TU** Connect J4-40 to J4-38; and J7-70 to J7-69.

## External Mode

Once the generated code is running on the C2000 target, the user can enter the External Mode to update Scopes in the PLECS application with real-time waveforms and change certain simulation parameters. The steps below outline how to connect to the target device, with additional debugging details provided in the “Start the External Mode” section of the user manual [9].

- First, from the **System** menu on the left hand side of the **Coder + Coder options...** window, select the desired MCU.
- Then, from the **External Mode** tab, select the **Target device** by clicking  icon next to the **Target device** field.
- Next, click **Connect** and then **Activate autotriggering** to observe the test results in the subsystem Scope.

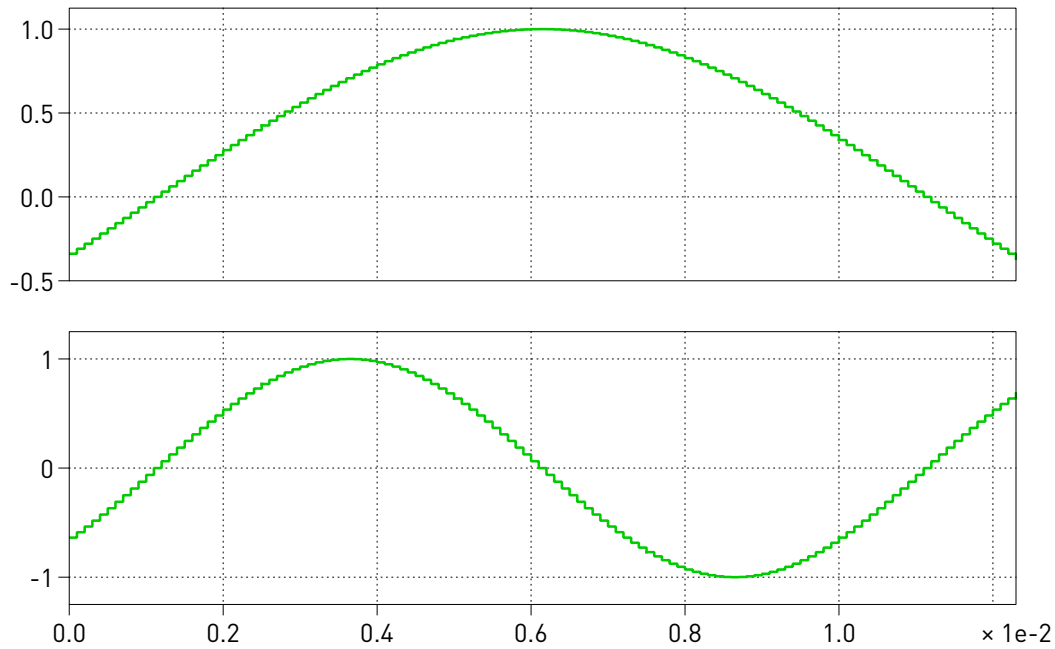
The generated sine waveforms can be viewed using the scope labeled "Sine", as shown in Fig. 5. The captured PWM and ADC signals can be viewed using the scope labeled "Scope", as shown in Fig. 6 and Fig. 7, found within the subsystem of the desired MCU. A trigger level for a desired **Trigger channel** can be set from the **External Mode** tab.

## Parameter Inlining

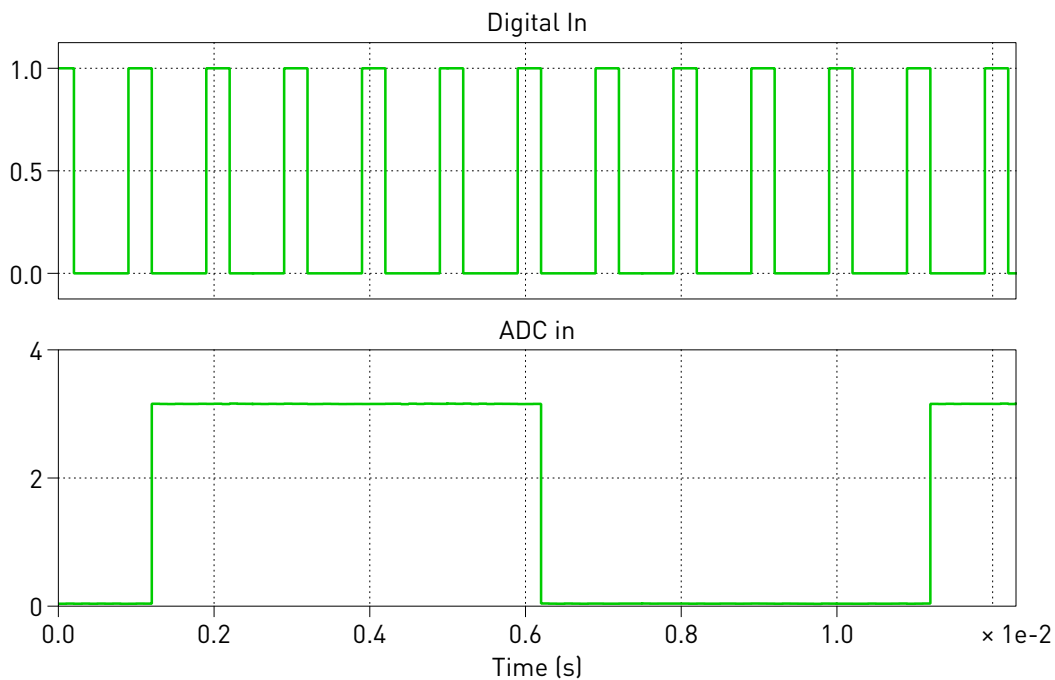
Certain values on the target device can be changed in real-time, if the component is added to the "Exceptions" list found in the **Parameter Inlining** tab of the **Coder options...** window, prior to building the model. In this case, the values labeled “Gain” and “duty” can be changed when connected to the target device via the External Mode. Changes in the parameters will be reflected in the Scope traces once they take effect.

# 4 Conclusion

This model demonstrates how to program a TI C2000 MCU, connect to the External Mode, and also demonstrates Parameter Inlining feature using a simple model.



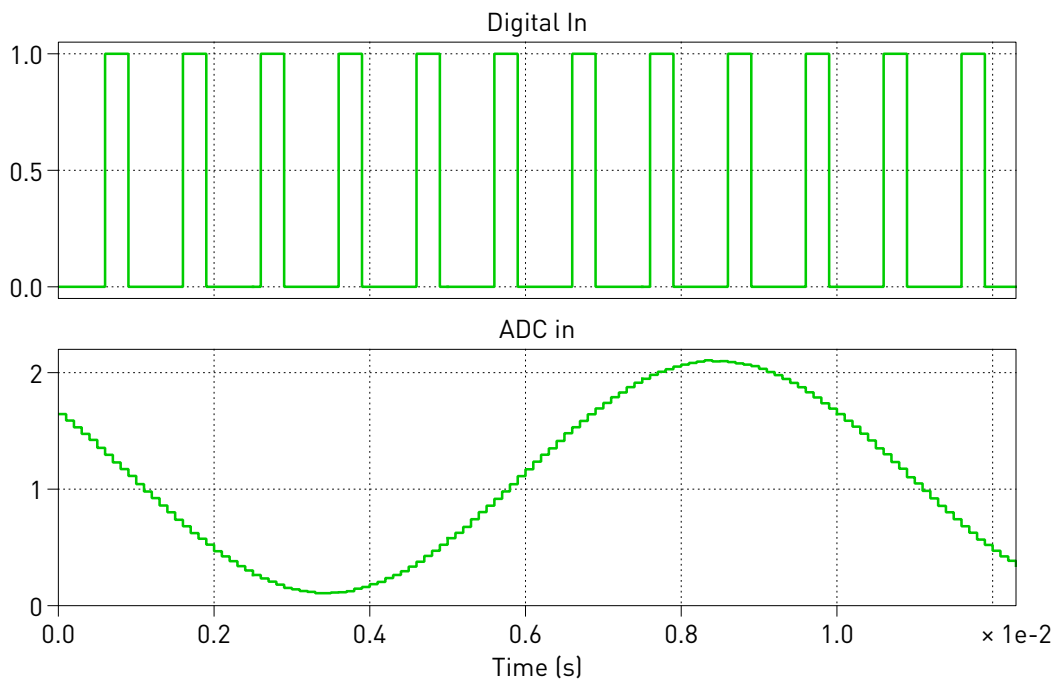
**Figure 5: Generated sine waveforms on the 28069**



**Figure 6: Captured PWM and ADC signals on the 28069**

## References

- [1] TI C2000 Piccolo MCU F28069M LaunchPad Development Kit,  
URL: <http://www.ti.com/tool/LAUNCHXL-F28069M>.
- [2] TI C2000 Piccolo MCU F280049C LaunchPad Development Kit  
URL: <http://www.ti.com/tool/LAUNCHXL-F280049C>.



**Figure 7: Captured PWM and ADC signals on the 280049**

- [3] TI C2000 Delfino MCUs F28377S LaunchPad Development Kit  
URL: <https://www.ti.com/lit/pdf/sprui25>
- [4] TI C2000 Delfino MCUs F28379D LaunchPad Development Kit,  
URL: <http://www.ti.com/tool/LAUNCHXL-F28379D>.
- [5] TI C2000 F280039C LaunchPad development kit,  
URL: <http://www.ti.com/tool/LAUNCHXL-F280039C>.
- [6] TI C2000 F28P650DK9 LaunchPad development kit,  
URL: <https://www.ti.com/tool/LAUNCHXL-F28P65X>.
- [7] TI C2000 F28P550SJ9 LaunchPad development kit,  
URL: <https://www.ti.com/tool/LAUNCHXL-F28P55X>.
- [8] TI C2000 F29H850TU LaunchPad development kit,  
URL: <https://www.ti.com/tool/LAUNCHXL-F29H85X>.
- [9] PLECS TI C2000 Target Support User Manual,  
URL: <https://www.plexim.com/sites/default/files/c2000manual.pdf>.

## Revision History:

C2000 TSP 1.2	First release
C2000 TSP 1.4.5	Updated the web links
C2000 TSP 1.6.1	Added support for 280039C LaunchPad target
C2000 TSP 1.9.1	Added support for 28P550SJ9 LaunchPad target

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