

# Piccolo™ F28004x Power Estimation Tool

Marlyn Rosales

## ABSTRACT

This user guide explains how to use the C2000 Piccolo F28004x Power Estimation Tool to estimate the device power consumption across various configurations and operating conditions. The information delivered by this tool is only applicable to the F28004x series in the C2000 product line of microcontrollers.

To download the tool, go to <http://www.ti.com/tool/C2000-F28004X-POWER-EST-CALC>.

## Contents

1	Introduction .....	1
2	General Information .....	1
3	Inputs/Outputs .....	3
4	References .....	7

## List of Figures

1	Piccolo F28004x Power Estimation Tool Layout .....	2
---	--	---

## Trademarks

Piccolo is a trademark of Texas Instruments.

## 1 Introduction

The purpose of this tool is to evaluate the overall power consumed on the F28004x device. It may not be enough to only use the data specified by the data manual, as it does not pertain to specific use cases and operating conditions. This tool encompasses a wider range of options that will provide the necessary information needed to estimate the power consumption of any application that uses the F28004x microcontroller.

---

**NOTE:** Throughout this document, many device features and capabilities are referenced. Describing the setup and specific details of these features are out of the scope of this document. For information on the various configurations and features of the F28004x MCU, see the documents located in the [Section 4](#).

---

## 2 General Information

### 2.1 Layout

The graphical user interface (GUI) is separated into two distinct sections: Inputs and Outputs. The Inputs section of the tool is grouped together with a white background while the outputs share a red background. [Figure 1](#) shows the Inputs outlined in green; the Outputs are outlined in red.

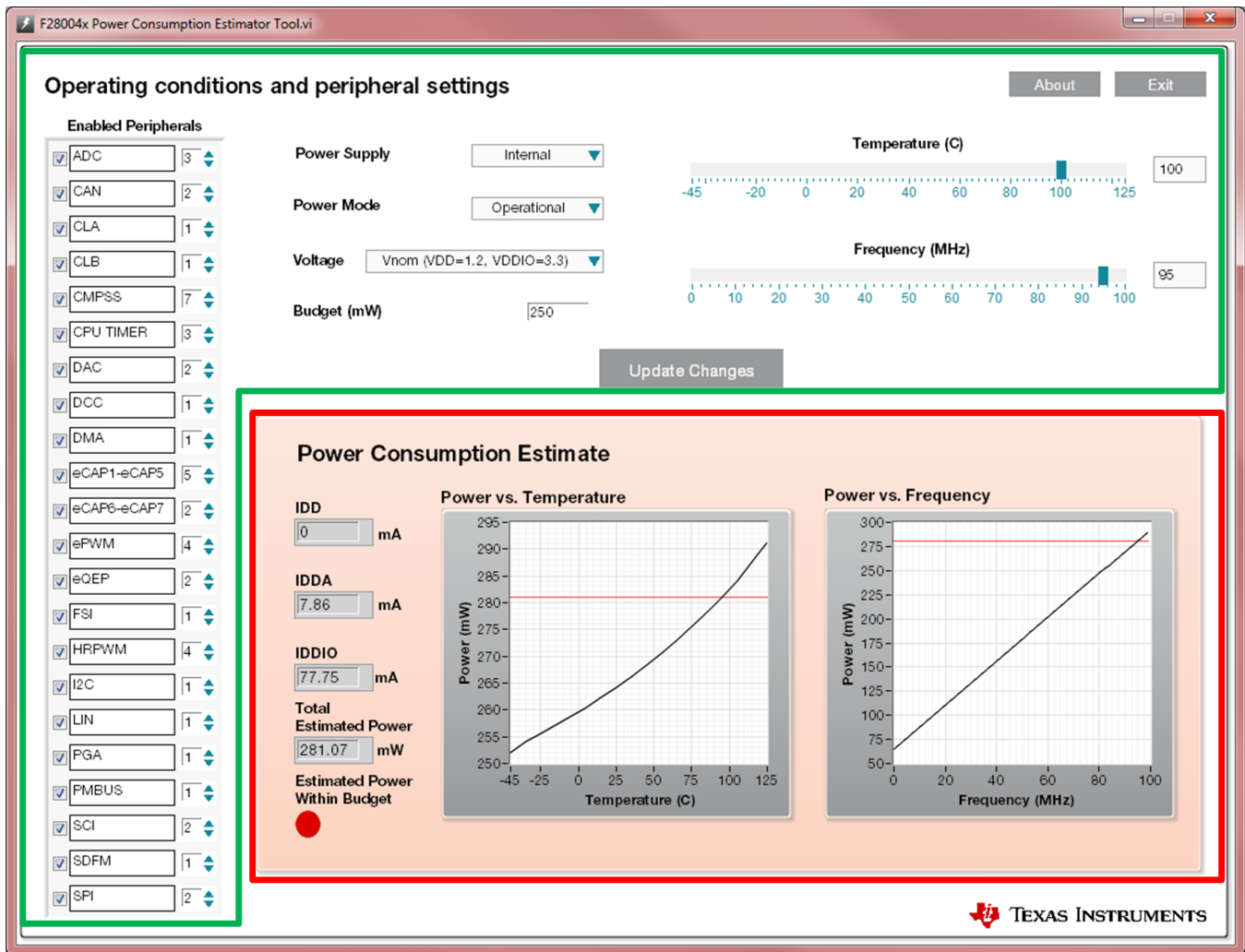


Figure 1. Piccolo F28004x Power Estimation Tool Layout

## 2.2 Data Collection Setup

Information for this device was obtained through Verification and Debugging Board (VDB) testing using units sampled from multiple silicon wafers. Power consumption data was collected across the full range of operational voltages, temperatures, and system clock frequencies to provide the underlying data that the GUI uses to estimate application-specific power consumption. The device was operating on a free-air temperature range.

For a description of the operational test case condition, refer to the device data manual.

## 2.3 Running the Executable

The tool will automatically run when the executable is opened. To open the executable double click on the Piccolo F28004x Power Estimation Tool.exe. By default, this will be located in the C:\ti\c2000 directory. When the executable opens for the first time, all inputs and outputs will be cleared and in their original state.

## 2.4 Terminating the Executable

To terminate the executable, press the Exit button on the top right corner of the tool. Alternately, the standard x in the upper right of the application may be used to exit the tool. Once the application is closed, all inputs and outputs will be cleared. Previously entered data will not be saved when the application is closed.

## 3 Inputs/Outputs

### 3.1 Inputs

All of the inputs of the tool can be found in the area outlined in green in [Figure 1](#). At any time, the Update Changes button must be pressed in order to update the outputs. The following sections describe each of the inputs and outputs and how to select them.

#### 3.1.1 Power Supply Configuration

The 1.2 V VDD supply of the F28004x MCU can be provided by one of three modes: External power supply, internal LDO regulator, or an internal DC-DC converter. The three options can be found under Power Supply in the top area of the tool. Clicking the drop-down will show the following list. Select which mode the application will use.

- External: VDD and VDDIO pins are supplied by an external power source.
- Internal: The internal LDO Voltage Regulator (VREG) is supplied by VDDIO and generates the 1.2 V required by the core VDD supply.
- DC-DC: The internal DC-DC switching regulator is supplied by the VDDIO\_SW pin and generates the 1.2 V required by the core VDD supply.

##### 3.1.1.1 Selecting a Power Supply Configuration

To select a power configuration press on the Power Supply control where Select is shown, and choose an option of either External, Internal, or DC-DC from the drop down menu. A power supply configuration can also be chosen by clicking on the up and down arrows presented on the control until the desired power supply configuration appears on the display.

#### 3.1.2 Power Mode

The F28004x MCU can run an application or enter into one of the two clock-gating low power modes. These can be selected by clicking the Power Mode drop-down and selecting the desired mode. The available modes are briefly described in the list below. For specific information about entering a low power mode or awakening from a low power mode refer to the Low Power Modes section of the TRM.

- Operational: In this mode the main system clock (SYSCLK) is running as well as any of the peripherals that have been enabled per the application requirements.
- IDLE: In this mode the CPU clock is gated while all enabled peripheral clocks are left running.
- HALT: In this mode almost all system clocks are gated. This is the lowest power consumption mode of F28004x.

##### 3.1.2.1 Selecting the Power Mode

To select a power mode, press on the Power Mode control where Select is shown and choose an option of either Operational, IDLE, or HALT from the drop down menu. A power mode can also be chosen by clicking on the up and down arrows presented on the control until the desired power mode appears on the display.

### 3.1.3 Operating Voltages

VDD is the core voltage. VDDIO is the voltage that is routed to the digital portion of the device. VDDA is the voltage that is routed to the analog portion of the device. For this application, both VDDA and VDDIO are shorted together and supplied by the same power source. The F28004x device may operate within a range of voltages bounded by VMIN and VMAX as described in the data manual. This tool limits the selection to one set of voltages determined by Vmin, Vnom, or Vmax found under the Voltage drop-down menu.

- Vmin (VDD=1.14V, VDDIO=3V)
- Vnom (VDD=1.2V, VDDIO=3.3V)
- Vmax (VDD=1.32V, VDDIO=3.6V)

#### 3.1.3.1 Selecting the Operating Voltages

To select a voltage configuration, press on the Voltage control where Select is shown and choose Vmin, Vnom, or Vmax from the drop down list. A voltage selection can also be chosen by clicking on the up and down arrows presented on the control until the desired power mode appears on the display.

When External is chosen as a Power Supply Configuration, each of the Voltage options will reflect the VDD and VDDIO specified in parenthesis. However, in the case when Internal or DC-DC is chosen as a Power Supply Configuration, the voltage selection will only be representative of the VDDIO voltage. VDD will remain fixed at a nominal, 1.2 V value.

### 3.1.4 Power Budget

The Power Budget selection is an input that is used to represent the desired upper limit of the application's power consumption. This value is not required by the tool. If no power budget is required, it may be left blank and the output ignored. Setting the Power Budget allows the application designer to visualize if the currently selected configuration fits within a desired limit. Some tweaks may be made to the configuration to fit the power within the budget.

#### 3.1.4.1 Selecting a Power Budget

To input a power budget enter in a value into the Budget control. Press the Enter key after inputting a value to ensure that the value is registered. If the power budget value entered is greater than the Final Power Value delivered by the tool, the Estimated Power Within Budget LED will turn GREEN indicating that the power value is within the provided limit. The LED will turn RED indicating that the estimated power consumption is greater than the provided limit.

### 3.1.5 Temperature

The F28004x device may operate within a temperature range of -40°C to 125°C. Any temperature within this range may be chosen as an input. The tool will round the temperature input to the nearest 5°C.

#### 3.1.5.1 Selecting the Temperature

Temperature input is represented in the Celsius scale. Click and drag the Temperature (C) slider to the left or right until the desired temperature is shown in the digital display to the right. Alternatively, click on the digital display to the right of the slider, enter in a value then press Enter.

### 3.1.6 SYSCLK Frequency

The F28004x device can operate with a SYSCLK up to 100 MHz. Any frequency within this range between 5 MHz and 100 MHz can be chosen as an input. For more information on configuring SYSCLK, see the [TMS320F28004x Piccolo™ Microcontrollers Data Manual](#). The tool will round the frequency input to the nearest 5 MHz.

### 3.1.6.1 Selecting the SYSCLK Frequency

Frequency input is represented in MHz. Click and drag the Frequency (MHz) slider to the left or right until the desired frequency is shown in the digital display to the right of the slider. Alternatively, click on the digital display to the right of the slider, enter in a value then press Enter.

### 3.1.7 Peripherals

The F28004x features many peripherals for real-time control applications. Depending on the application, not all peripherals may be used. The peripheral clocks for unused peripherals may be disabled in order to conserve power. The very left side of the tool features a list of all of the peripherals available on the device. The peripherals are listed in alphabetical order as shown below:

- Analog-to-Digital Converter (ADC)
- Controller Area Network (CAN)
- Control Law Accelerator (CLA)
- Configurable Logic Block (CLB)
- Comparator Subsystem (CMPSS)
- CPU TIMER
- Digital-to-Analog Converter (DAC)
- Digital Clock Compare (DCC)
- Direct Memory Access (DMA)
- Enhanced Capture (eCAP1-eCAP5)
- Enhanced Capture (eCAP6-eCAP7) <sup>(1)</sup>
- Enhanced Pulse Width Modulator (ePWM)
- Enhanced Quadrature Encoder Pulse (eQEP)
- Fast Serial Interface (FSI)
- High-Resolution Pulse Width Modulator (HRPWM) <sup>(2)</sup>
- Inter-Integrated Circuit (I2C)
- Local Interconnect Network (LIN)
- Programmable Gate Array (PGA)
- Power Management Bus (PMBUS)
- Serial Communications Interface (SCI)
- Sigma-Delta Frequency Modulator (SDFM)
- Serial Peripheral Interface (SPI)

If HALT is chosen as the Power Mode for the system, any changes made to the peripheral selection will have no effect on the power as there cannot be any peripheral activity under this power modes. Even if the peripherals are still selected, they will not be factored into the final power value or graphs.

### 3.1.8 Selecting Peripherals

Each row in the chart corresponds to the peripheral specified. Peripheral selection is only indicative of peripheral clocks being enabled. For analog peripherals, the IDDA current will also be reflective of changes made to those peripherals.

To choose a peripheral, click on the empty box located on the left of the peripheral until a check mark appears. When choosing a peripheral, also indicate how many of each is being used by clicking the up and down arrows of the digital display to the right of the peripheral name, or by entering in a value into the digital display. If entering in a value manually, press enter to register the value. Both a check mark and a quantity must be selected for the output to include the power from that peripheral.

<sup>(1)</sup> eCAP6 and eCAP7 can also be configured as HRCAP

<sup>(2)</sup> HRPWM refers to the HRPWM clock, though each ePWM channel may be have HRPWM features enabled, there is a single HRPWM clock.

The tool will not allow the user to enable more instances of a module than are present on the F28004x MCU. To check the max number of modules per peripheral, see the [TMS320F28004x Piccolo™ Microcontrollers Data Manual](#). For example, there are only three ADC modules on the F28004x device; therefore, only three ADC modules can be enabled in the tool.

To disable any of the peripherals, simply uncheck the box that corresponds to the desired peripheral then press the Update Changes button. The number of modules per peripheral does not need to be changed back to zero when the check box is empty.

## 3.2 Outputs

The outputs of the tool can be found in the lower right area of the tool. The outputs section is outlined in red in [Figure 1](#). The outputs will only be updated when the Update Changes button has been pressed.

### 3.2.1 IDD

IDD represents the current consumed by the core of the device (VDD). Once all input parameters have been selected and the Update Changes button has been pressed, an IDD value will be shown. The unit for this value is mA. The value will be rounded up to the nearest 0.1 mA.

### 3.2.2 IDDA

IDDA represents the current consumed by the analog portion of the device (VDDA). Once all input parameters have been selected and the Update Changes button has been pressed, an IDDA value will be shown. The unit for this value is mA. The value will be rounded up to the nearest 0.1 mA.

### 3.2.3 IDDIO

IDDIO represents the current consumed by the digital portion of the device (VDDIO). Once all input parameters have been selected and the Update Changes button has been pressed, an IDDIO value will be shown. The unit for this value is mA. The value will be rounded up to the nearest 0.1 mA.

### 3.2.4 Total Estimated Power

The total estimated power value is a calculated output that combines the selected voltages and resulting currents based on the other inputs to the tool. This represents the overall power consumption of the device in the selected configuration. The unit for this value is mW. The value will be rounded up to the nearest 0.1 mW.

### 3.2.5 Power vs. Frequency Graph

The Power consumption of the device and the SYSCLK frequency have a linear relationship that can be seen in the Power vs. Frequency graph. The graph will only update after the Update Changes button has been clicked.

The red line on the graph intersects the Power vs. Frequency curve at the selected frequency.

If HALT mode is selected, the Power vs. Frequency will go blank as all clocks on the device will be gated.

### 3.2.6 Power vs. Temperature Graph

The Power consumption of the device and the operating temperature have an exponential relationship, which can be seen in the Power vs. Temperature graph. The graph will only update after the Update Changes button has been clicked.

The red line on the graph intersects the Power vs. Temperature curve at the selected Temperature.

In the HALT power mode the Power vs. Temperature graph represents the device leakage current across temperature. No peripherals, or frequency will be taken into account.

#### 4 References

- <http://www.ti.com/tool/C2000-F28004X-POWER-EST-CALC>
- *TMS320F28004x Piccolo™ Microcontrollers Data Manual*
- *TMS320F28004x Piccolo Microcontrollers Technical Reference Manual*

## IMPORTANT NOTICE FOR TI DESIGN INFORMATION AND RESOURCES

Texas Instruments Incorporated ("TI") technical, application or other design advice, services or information, including, but not limited to, reference designs and materials relating to evaluation modules, (collectively, "TI Resources") are intended to assist designers who are developing applications that incorporate TI products; by downloading, accessing or using any particular TI Resource in any way, you (individually or, if you are acting on behalf of a company, your company) agree to use it solely for this purpose and subject to the terms of this Notice.

TI's provision of TI Resources does not expand or otherwise alter TI's applicable published warranties or warranty disclaimers for TI products, and no additional obligations or liabilities arise from TI providing such TI Resources. TI reserves the right to make corrections, enhancements, improvements and other changes to its TI Resources.

You understand and agree that you remain responsible for using your independent analysis, evaluation and judgment in designing your applications and that you have full and exclusive responsibility to assure the safety of your applications and compliance of your applications (and of all TI products used in or for your applications) with all applicable regulations, laws and other applicable requirements. You represent that, with respect to your applications, you have all the necessary expertise to create and implement safeguards that (1) anticipate dangerous consequences of failures, (2) monitor failures and their consequences, and (3) lessen the likelihood of failures that might cause harm and take appropriate actions. You agree that prior to using or distributing any applications that include TI products, you will thoroughly test such applications and the functionality of such TI products as used in such applications. TI has not conducted any testing other than that specifically described in the published documentation for a particular TI Resource.

You are authorized to use, copy and modify any individual TI Resource only in connection with the development of applications that include the TI product(s) identified in such TI Resource. NO OTHER LICENSE, EXPRESS OR IMPLIED, BY ESTOPPEL OR OTHERWISE TO ANY OTHER TI INTELLECTUAL PROPERTY RIGHT, AND NO LICENSE TO ANY TECHNOLOGY OR INTELLECTUAL PROPERTY RIGHT OF TI OR ANY THIRD PARTY IS GRANTED HEREIN, including but not limited to any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information regarding or referencing third-party products or services does not constitute a license to use such products or services, or a warranty or endorsement thereof. Use of TI Resources may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

TI RESOURCES ARE PROVIDED "AS IS" AND WITH ALL FAULTS. TI DISCLAIMS ALL OTHER WARRANTIES OR REPRESENTATIONS, EXPRESS OR IMPLIED, REGARDING TI RESOURCES OR USE THEREOF, INCLUDING BUT NOT LIMITED TO ACCURACY OR COMPLETENESS, TITLE, ANY EPIDEMIC FAILURE WARRANTY AND ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, AND NON-INFRINGEMENT OF ANY THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

TI SHALL NOT BE LIABLE FOR AND SHALL NOT DEFEND OR INDEMNIFY YOU AGAINST ANY CLAIM, INCLUDING BUT NOT LIMITED TO ANY INFRINGEMENT CLAIM THAT RELATES TO OR IS BASED ON ANY COMBINATION OF PRODUCTS EVEN IF DESCRIBED IN TI RESOURCES OR OTHERWISE. IN NO EVENT SHALL TI BE LIABLE FOR ANY ACTUAL, DIRECT, SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF TI RESOURCES OR USE THEREOF, AND REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

You agree to fully indemnify TI and its representatives against any damages, costs, losses, and/or liabilities arising out of your non-compliance with the terms and provisions of this Notice.

This Notice applies to TI Resources. Additional terms apply to the use and purchase of certain types of materials, TI products and services. These include; without limitation, TI's standard terms for semiconductor products (<http://www.ti.com/sc/docs/stdterms.htm>), [evaluation modules](#), and [samples](http://www.ti.com/sc/docs/sampterm.htm) (<http://www.ti.com/sc/docs/sampterm.htm>).

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
Copyright © 2017, Texas Instruments Incorporated