

## **controlSUITE™ Getting Started Guide**

controlSUITE is a comprehensive suite of software for C2000™ microcontrollers that significantly decreases development time and includes features to improve usability. Designed to be both a learning tool and development platform, controlSUITE accommodates different experience levels and programming preferences.

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## 1 Main Features

controlSUITE's main features include:

- Centralized location for all C2000 software
- Intelligent installer that eliminates dependencies and version compatibility
- Organization of all software in a clean, intuitive file structure
- Three different approaches to MCU programming for the developer to choose from
- Modular software libraries and examples for throughout every design stage
- Application libraries and frameworks dedicated to popular application areas, including digital motor control and digital power conversion
- Complete system development platforms with open-source hardware and software
- Thorough support documentation that provides implementation details as well as theoretical background

### 1.1 Current Features List

controlSUITE will be released in phases. The current release contains the following components:

#### Development Kits

- Piccolo controlSTICK (TMDX28027USB)
  - With Piccolo F2802x
- High Voltage Motor Control Kit (TMDSHVMTRPFCKIT)
  - With Piccolo F2803x
  - With Delfino F2833x
- High Voltage Power Factor Correction Kit (TMDSHVPFCKIT)
  - With Piccolo F2802x
- Low Voltage Motor Control Kit (TMDS1MTRPFCKIT and TMDS2MTRPFCKIT)
  - With Piccolo F2803x
- LED DC/DC Lighting Kit (TMDSDCDCLEDKIT)
  - With Piccolo F2803x

#### Device Support Packages

- Piccolo F2802x, Piccolo F2803x, Delfino F2833x, Delfino C2834x
  - Bit Fields
  - Peripheral Examples
  - Hardware Developer's Package

#### Libraries

- Digital Motor Control Library
  - For C28x core (on all C2000 28x microcontrollers)
- Digital Power Library
  - For C28x core (on all C2000 28x microcontrollers)
  - For Control Law Accelerator (CLA)
- Math Libraries
  - Fixed-Point (IQMath)
  - Floating Point (fastRTS Library)
  - CLA
- Utilities
  - Flash API (for all Piccolo and Delfino devices)
  - Boot ROM source code (for all Piccolo and Delfino devices)

## 1.2 Feature Descriptions

This section details the features included in the current release of controlSUITE.

### 1.2.1 Application Kits

#### Piccolo controlSTICK

The innovative Piccolo controlSTICK allows quick and easy evaluation of all of the advanced capabilities of TI's new Piccolo microcontroller for just \$39. Slightly larger than a memory stick, the Piccolo controlSTICK features on board emulation and access to all the I/O pins. Example projects walk through all the functionality of Piccolo, from simply blinking an LED to configuring the high resolution ePWM peripherals.

The Piccolo controlSTICK projects are built on a system framework that can be used in any project to eliminate the need to develop from scratch. The framework includes task management, GPIO mappings, and more. Look for the "controlSTICK Examples Overview" document in the controlSTICK documents folder for more information.

#### High Voltage Digital Motor Control and PFC Kit

Supporting three different kinds of motors, this high-voltage kit demonstrates a closed-loop motor control system that closely resembles real-world applications, both sensed and sensorless. The board includes an efficient power factor correction stage that can handle up to 750W, and the motor stage can provide up to 1.5KW of power. Motor types supported are AC Induction (ACI), Permanent Magnet Sinusoidal (PMSM), and Brushless DC (BLDC).

#### Motor Control and PFC Developer's Kit and Dual Motor Control and PFC Developer's Kit

The Motor Control and PFC Developer's Kit and Dual Motor Control and PFC Developer's Kit from Texas Instruments leverages the real-time control capabilities of Piccolo, along with TI's industry leading analog, to bring field-oriented motor control and power factor correction into cost-sensitive applications. The kit includes everything needed to start development: a motor control baseboard with onboard isolated USB JTAG emulation, F28035 controlCARD, two permanent magnet motors, and a desktop DC power supply. The software included with this kit controls up to two permanent magnet motors using sensorless field-oriented control techniques, and is tuned for the motors included with the kit. The software also digitally controls the two-phase interleaved power factor correction (PFC) stage.

#### High Voltage Power Factor Correction Kit

The High Voltage Power Factor Correction Kit can take line-level AC and convert it to up to 400VDC with two-phase interleaved power factor correction. The kit demonstrates the intelligence and flexibility that digital power brings: software can adjust for different load conditions by shedding phases or varying output, and the DC output voltage can change for more precision at lower loads. This kit also includes a graphical user interface for quick evaluation by providing the ability to modify parameters on the fly, and a graph to display the effects on input current and voltage.

#### DC/DC Lighting Developer's Kit

The LED DC/DC Developer's Kit includes all of the hardware and software needed to start experimenting and developing a digitally controlled LED DC/DC system. The kit is based on the Piccolo microcontroller and the controlCARD development platform. One Piccolo MCU is able to directly control the DC/DC power stage as well as eight LED strings. The development board takes 12-48V DC of input and uses a SEPIC DC/DC topology to buck or boost the input voltage to a desired level. This voltage is then fed to four LED driving stages, each capable of driving two LED strings at up to 30 watts each. The kit also includes closed loop, open source software for both the DC/DC stage and the LED lighting stage.

### 1.2.2 Device Support

controlSUITE currently supports all Piccolo and Delfino devices, which includes the following:

- TMS320F28035
- TMS320F28034
- TMS320F28033
- TMS320F28032

- TMS320F28031
- TMS320F28030
- TMS320F28027
- TMS320F28026
- TMS320F28023
- TMS320F28022
- TMS320F28021
- TMS320F28020
- TMS320F280200
- TMS320F28335
- TMS320F28334
- TMS320F28332
- TMS320C28346
- TMS320C28345
- TMS320C28344
- TMS320C28343
- TMS320C28342
- TMS320C28341

#### 1.2.2.1 **Piccolo F2802x**

Bringing C2000 to a new level of performance, integration, and low-cost, Piccolo F2802x devices combine the math capabilities of the C28x core with high-precision peripherals and analog integration all in a low-cost solution. Piccolo features C2000's unique high-resolution PWMs, industry-leading high-speed ADC, and a host of other modules such as high-precision on-chip oscillators, analog comparators, and communication interfaces. The initial release of controlSUITE contains the bit field headers as well as an exhaustive set of examples for the device and peripherals. For more information, refer to the quick-start readme within the device support directory.

#### 1.2.2.2 **Piccolo F2803x**

Expanding on the F2802x line, Piccolo F2803x introduces a new concept to microcontrollers – an independent, floating-point Control Law Accelerator (CLA). With the ability to run control loops and control peripherals independent of the core, the CLA significantly boosts the capability of Piccolo MCUs. F2803x also includes an expanded Flash size and increased number of peripherals, as well as CAN and LIN communication interfaces.

#### 1.2.2.3 **Delfino F2833x**

The F2833x's integrated floating-point unit simplifies development and speeds control applications up by an average of 50%. F2833x devices run at up to 150 MHz (300 MFLOPS) with two-package offerings that are pin-for-pin compatible within all F2833x and F2823x controllers. It also features up to 512KB of on-chip flash and a DMA for high speed memory access.

#### 1.2.2.4 **Delfino C2834x**

Building on TI's existing F2833x high-performance floating-point microcontrollers, the C2834x delivers up to 600 MFLOPS of floating-point performance, up to 516KB of single-access RAM, and PWMs with 65-ps. Direct memory access and a low-latency core make the C2834x an excellent solution for performance-hungry, real-time control applications.

### 1.2.3 Libraries

#### Fixed-point Math Library (IQMath)

IQMath brings the power of floating point to fixed-point microcontrollers. IQMath is a library and compiler intrinsic that allows you to select your range and resolution. It allows you to write C functions in floating point format instead of dealing with fixed-point scaling, and the compiler takes care of the rest.

The fixed-point math library uses IQMath for a variety of functions. See the IQMath documentation for more information.

#### Floating-point Math Library (fastRTS)

The C28x fastRTS is a collection of optimized floating-point math functions for C programmers of the C28x with Floating-Point unit. Designers of computationally-intensive, real-time applications can achieve execution speeds considerably faster than what are currently available, without having to rewrite existing code. The functions listed in the features section are specifically optimized for the C28x + FPU controllers.

#### CLA Math Library

The CLA math library provides a set of functions for use with the CLA. See the CLAMath documentation for more information.

#### Digital Motor Control Library

The digital motor control library provides a set of modular macros designed for easy use and customization. Focused on high precision and accuracy, this optimized library makes it simple to implement advanced motor control algorithms and easily tune it for your custom motor. The library includes source code as well as documentation and theory

#### Digital Power Library

The Digital Power Library is a collection of software blocks that can be used to easily build the control loop. Implementing different control methods is as easy as changing the connections to make sure the inputs and outputs go to the right places. The library contains mathematical blocks, such as the 2pole 2zero controller, as well as driver blocks for different topologies. With these two components, the learning curve and development time for digital power software is significantly reduced. The software blocks are provided as source code. The Digital Power Library contains a set for the C28x core as well as a set for the CLA.

#### Utilities

This folder contains various utilities for use with controlSUITE supported MCUs.

- **Flash API** The Flash API enables field updates of program memory. See the Flash API documentation for more information.
- **Boot ROM Source Code** The boot ROM is factory programmed with boot-loading software. The Boot ROM reference guide can be found here, which includes the link to download the Boot ROM source code.

## 1.3 Revision History

Version 1.1

This version is the second phase of controlSUITE - July 6, 2010

## 2 Getting Started

controlSUITE begins with the installer. This installer serves three main purposes.

- Provides a comprehensive listing of C2000 software resources, eliminating the need to dig through multiple web pages
- Detects, downloads, and installs dependencies
- Provides a means for update notification

### 2.1 Installing Software

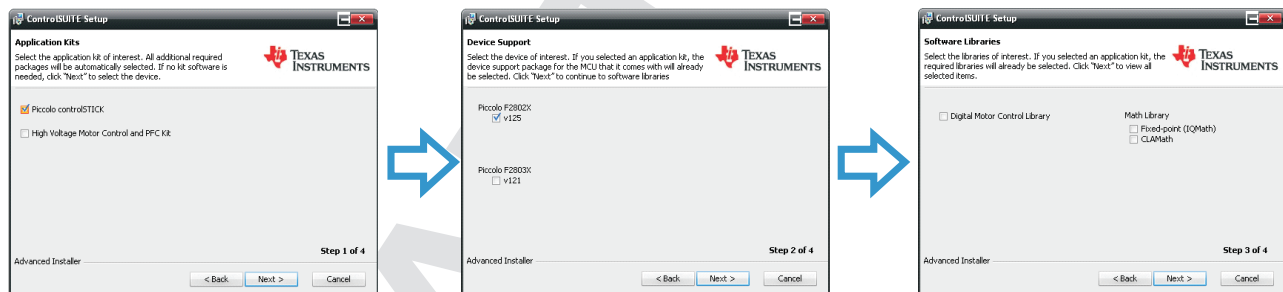
The controlSUITE installer itself is a small file because the initial download does not include any actual software. The installer represents a portal to all of C2000 software.

When running the installer, there will be several dialogs that require user input. First, after accepting the End User License Agreement, the installer gives the option of changing the installation directory. The default installation directory (C:\TI) is highly recommended. Although there should not be any problems associated with changing the installation directory, it is possible that changing the directory could require minor changes to the code to accommodate the different location.

The next three dialogs show software packages.

- The first dialog shows C2000 application and development kit options. If you have purchased a kit, make the selection here. Contents are described in [Section 1.2.1](#).
- Each kit comes with a packaged controlCARD, and the corresponding device support package will be automatically selected (see [Figure 1](#)). If a specific library is required, it will be automatically selected as well. If no kit software is required, simply click “Next” to go to the next screen.
- The third dialog shows all of the libraries. A kit selection will automatically select the required libraries. If you would like to install other libraries, make your selection here.

**Figure 1. Library Selection**



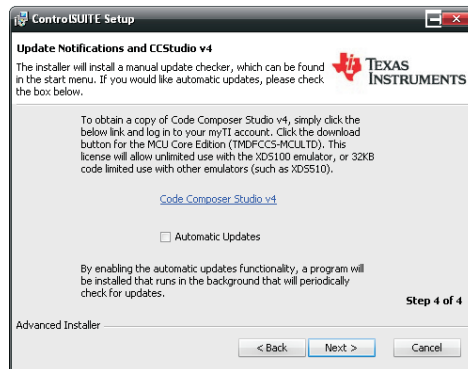
Select the desired software in three steps. Dependencies are automatically selected, as shown above using the Piccolo controlSTICK as an example. Since the F2802x device support package is required, selecting Piccolo controlSTICK on the Application Kits screen will automatically select Piccolo F2802x on the Device Support screen.

A fourth step points to the Code Composer Studio™ v4 download site as well as presents the option to install an automatic update background process. This is described in the next section.

A summary page at the end will display all the selected components as well as a disk space indicator.

### 2.2 Update Notifications

The next dialog screen allows the user to select the option to install an automatic update checker. The installer always installs a manual “Check for updates” application. This requires the user to run the application, which checks the server for updates. The automatic updates feature installs a background process that periodically checks the server and notifies the user when updates are found.

**Figure 2. Code Composer Studio Automated Updates**


### 2.3 Code Composer Studio v4

Code Composer Studio v4 can be obtained from the following website:

<http://focus.ti.com/docs/toolsw/folders/print/ccstudio.html>

This website is also found in Step 4 of the installer.

All projects and examples in controlSUITE are built for and tested with TI's Code Composer Studio v4. Although Code Composer Studio is not included with the controlSUITE installer, it is easily obtainable in a variety of versions. There are two free versions that can be used for free.

- XDS100-limited license(CCS-FREE, Full DVD Image) This license is completely free for use with the XDS100, which is used by all C2000 tools with on-board emulation. This version is recommended for C2000 developers using low-cost emulation. Click on CCS-Free, download the Full DVD image, and obtain the Bundle License for DSKs and EVM kits.
- MCU Edition (CCS-Free, Code Size Limited Image) This version is completely free for use with TI MCUs, but it is code-size limited. For C2000 devices, it will only program 32KB of code. This version is recommended for users who also program with the MSP430. Note: this version does NOT include DSP/BIOS.

## 3 controlSUITE Desktop

controlSUITE Desktop enables users to easily access software and documentation for kits and devices. controlSUITE Desktop also helps to find online resources such as user guides, the best application notes, and training.

**Figure 3. controlsuite Desktop**


## Devices, Kits, and Libraries

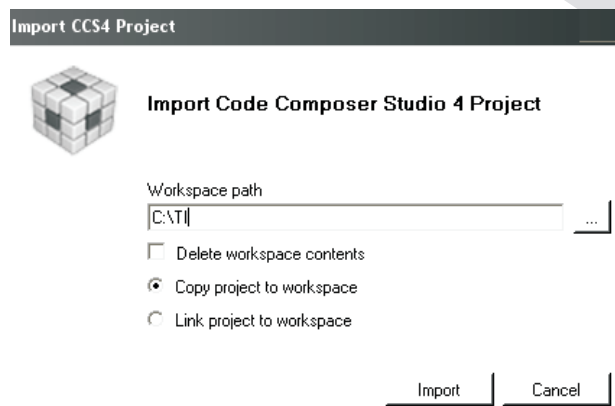
controlSUITE Desktop contains entries for all devices, kits and libraries included in controlSUITE. Each entry contains a summary as well as any example projects, documentation, online resources, and other useful content.

## Example Projects

Each kit and devices contains a set of example projects. The list of projects may not represent all available projects. Click on the “Open example projects folder” to view the actual folder.

When double-clicking an example project, the controlSUITE Desktop will attempt to directly open the project, at which point you will be presented with the screen shown in [Figure 4](#).

**Figure 4. Import CCS4 Project**



- Choose the workspace you want to use (can be the same as current workspace with CCSv4).
- Select “Copy project to workspace” if you would like to create a copy of the project in the desired workspace. From then on, you will be able to access this copy by directly opening CCSv4.
- Select “Link project to workspace” to directly modify the project. The danger of opening it this way is that the project WILL be overwritten when an update is installed. Make sure to back up the project when any user modifications are made.

## Files, Folders, and Links

Double clicking on files, folders, and links will directly open the described resource.

### 3.1 Working Outside the controlSUITE Framework

All projects are setup to use relative paths to find header files, command linker files and static libraries within the framework of controlSUITE. If the user wishes to develop or modify example code outside this framework, the following steps must be taken to ensure that the correct resources are pulled in at compile time:

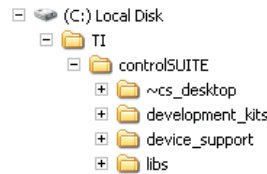
1. Copy the example in a new working directory.
2. Import the project into Code Composer Studio.
3. Modify the file *macros.ini* to use absolute paths instead of the default relative paths.
4. Delete the project from within Code Composer Studio.
5. Re-import the project into Code Composer Studio.

The last two steps are important. CCSv4 only reads the paths from *macros.ini* on project import.

## 4 Directory Structure

With controlSUITE, all C2000 software is organized into a consolidated, intuitive file structure

**Figure 5. controlSUITE Main File Structure**



As installed, controlSUITE files are all located in one location: C:\TI\controlSUITE. There are four categories of software, as described in [Table 1](#).

**Table 1. controlSUITE Main Directories**

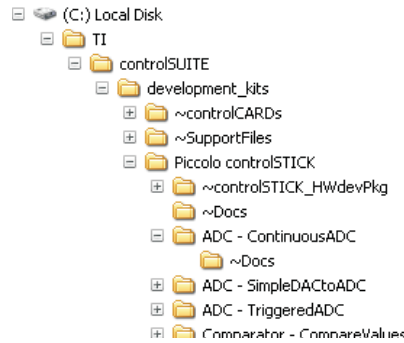
Directory	Description
development_kits	All development kit software will be located in this directory. Files include full projects, support files, and hardware developer's packages.
device_support	All device-specific software files will be located in this directory. This includes the bit field header files and peripheral examples.
libs	All library files will be located in this directory. This includes math libraries, application libraries, and utilities.
~cs_desktop	All controlSUITE Desktop support files are located in this directory. Please do not modify these files.

### 4.1 Development Kit Software

Each development kit will have its own folder. In addition, there will be two support directories (indicated with a ~ in front of the name):

- **~controlCARDS** Because controlCARDS are independent of kits, the hardware files will be stored in the "controlCARDS" folder. The hardware files include:
  - Bill of Materials
  - Schematics and Layouts
  - Gerbers
  - Pin descriptions
  - Associated datasheets
- **~SupportFiles** This folder includes additional header files common to development kits such as peripheral addresses defined for assembly usage and other common definitions.
- **Kit Folders.** Each development kit will have its own folder. To illustrate the structure, let's take a look at the Piccolo controlSTICK folder in [Figure 6](#). First, there is the hardware developer package folder, with the same hardware files as listed under the controlCARDS hardware package above.
  - A "~Docs" folder contains the Quick Start Guide and other documentation associated with the kit as a whole (setting up the board, GUI, etc).
  - Each project will have its own folder as well. These projects are built for use with Code Composer Studio v4 and represent an independent laboratory using some or all of the features of the board. If there is additional documentation for the project, it will be located in a "~Docs" folder under the project folder. For example, the ADC continuous sampling example contains pin connection information, software setup steps, and other information specific to the project.

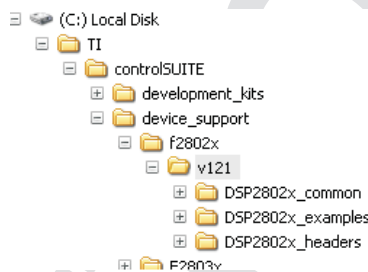
**Figure 6. Development Kit File Structure Example – Piccolo controlSTICK**



### 4.2 Device Support Software

Each device family will have its own device support folder. For each device, the support packages are separated by version. Versions will be independently downloadable in order to preserve compatibility with other software. Each version will have subfolders as illustrated in Figure 7 and described in Table 2.

**Figure 7. Device Support Sub-Directories Example: Piccolo F2802x**



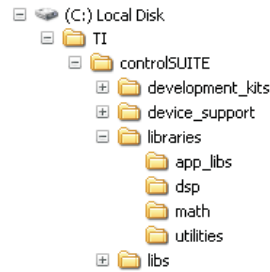
**Table 2. Device Support Sub-directories**

Directory	Description
~Docs	Documentation, including walkthroughs, tips, FAQs, and revision history from the previous release.
<device>_examples	Example Code Composer Studio v4.0+ projects. These example projects illustrate how to configure many of the on-chip peripherals.
<device>_headers	Files required to incorporate the peripheral header files into a project .
<device>_common	Common source files shared across example projects to illustrate how to perform tasks using header file approach. Use of these files is optional, but may be useful in new projects.

For more details, see the Quick Start Guide located in each device support folder.

### 4.3 Library Repository

Each type of library will have its own subdirectory. Initially, there are four types of libraries, as illustrated in Figure 8 and described in Table 3.

**Figure 8. Libraries Folder Structure**

**Table 3. Library Types**

Directory	Description
app_libs	Application libraries contain modular, application-specific functions and macros.
math	Basic math libraries, including trig, sqrt, etc.
dsp	DSP libraries, including vector and matrix math, FFTs, filters, etc.
utilities	Miscellaneous libraries and utilities, such as boot ROM source code and Flash API libraries.

For more details, see the documentation located within in each library.

## 5 Future Features List

Future releases of controlSUITE will incrementally add more software. Some of the planned future software includes, but is not limited to:

- Device Support
  - Peripheral API drivers
- Application Kits
  - Piccolo F28027 Experimenter's Kit
  - Piccolo F28035 Experimenter's Kit
  - Delfino F28335 Experimenter's Kit
  - Delfino C28343 Experimenter's Kit
  - Peripheral Explorer Kit
- Libraries
  - FFT Libraries
  - Filter Libraries
  - Power Line Communication Library

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Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

### Products

Audio	<a href="http://www.ti.com/audio">www.ti.com/audio</a>
Amplifiers	<a href="http://amplifier.ti.com">amplifier.ti.com</a>
Data Converters	<a href="http://dataconverter.ti.com">dataconverter.ti.com</a>
DLP® Products	<a href="http://www.dlp.com">www.dlp.com</a>
DSP	<a href="http://dsp.ti.com">dsp.ti.com</a>
Clocks and Timers	<a href="http://www.ti.com/clocks">www.ti.com/clocks</a>
Interface	<a href="http://interface.ti.com">interface.ti.com</a>
Logic	<a href="http://logic.ti.com">logic.ti.com</a>
Power Mgmt	<a href="http://power.ti.com">power.ti.com</a>
Microcontrollers	<a href="http://microcontroller.ti.com">microcontroller.ti.com</a>
RFID	<a href="http://www.ti-rfid.com">www.ti-rfid.com</a>
RF/IF and ZigBee® Solutions	<a href="http://www.ti.com/lprf">www.ti.com/lprf</a>

### Applications

Communications and Telecom	<a href="http://www.ti.com/communications">www.ti.com/communications</a>
Computers and Peripherals	<a href="http://www.ti.com/computers">www.ti.com/computers</a>
Consumer Electronics	<a href="http://www.ti.com/consumer-apps">www.ti.com/consumer-apps</a>
Energy and Lighting	<a href="http://www.ti.com/energy">www.ti.com/energy</a>
Industrial	<a href="http://www.ti.com/industrial">www.ti.com/industrial</a>
Medical	<a href="http://www.ti.com/medical">www.ti.com/medical</a>
Security	<a href="http://www.ti.com/security">www.ti.com/security</a>
Space, Avionics and Defense	<a href="http://www.ti.com/space-avionics-defense">www.ti.com/space-avionics-defense</a>
Transportation and Automotive	<a href="http://www.ti.com/automotive">www.ti.com/automotive</a>
Video and Imaging	<a href="http://www.ti.com/video">www.ti.com/video</a>
Wireless	<a href="http://www.ti.com/wireless-apps">www.ti.com/wireless-apps</a>

TI E2E Community Home Page

[e2e.ti.com](http://e2e.ti.com)

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