# C2000(TM) Real-Time **Microcontrollers** Overview

## SLIDE 1:

**PRESENTER:** C2000 is a microcontroller family focused on real-time control. Real time control systems require fast on time responses to inputs and outputs. To illustrate what this means, let's use video as an example. If you're encoding a video you don't really care how long it takes. A 30 minute video can take one hour to process. And that's OK. This represents a standard control system. However if a human is watching the video, each frame they see encoded on a strict time schedule. It's unacceptable to skip frames or slow it down. This represents a real-time control system. And that's where C2000 strives. You'll see that applications C2000 is strong in include digital power, digital motor control, position sensing, automotive radar, and much more. So what makes C2000 so good at real-time control? C2000's strength is that it combines the best from the processing performance world and combines it with the system integration and ease of use of the microcontroller world. With C2000's DSP lineage, it features high performance and control optimized processing and in both fixed point and floating point variance. On the flip side, C2000 features powerful peripherals, including integrated embedded Flash and integrated analog components that you don't get with a DSP. C2000 also includes software and tools that make it easy to use and develop with.

## SLIDE 2:

**C2000(TM): The ideal solution for real-time control**
Let's take a little closer look at those components. At the heart of C2000 devices is a 32-bit CPU called the C28X core. It can range from 40 to 3000 megahertz, and it also features floating point as an option. We also include control law accelerators on some of our devices, which is essentially a second core that runs in parallel with the CPU and has independent control to the peripherals. Another strong points of C2000 is the system integration. I mentioned earlier how we featured integrated analog. And that includes dual on-chip high precision oscillators-- so you don't need any external crystals--, on-chip voltage regulation, and analog comparators as well. We've combined this with an enhanced pulse width modulation that has a slew of features dedicated to make the best of motor control and digital power possible, as well as an enhanced capture as well as QEP for motor control. We include up to 512 kilobytes of on-chip Flash and also up to 516 kilobytes of on-chip RAM in some of our devices. We feature all of the necessary serial communications, such as I-squared-C, SPI, UART, CAN, as well as differentiated components such as USB and Ethernet. With C2000 you get a broad portfolio of configurations. The Piccolo device starts at 40 megahertz and a result the way up to 300 megahertz. And all the devices in between are code compatible. We've also spent a lot of time to make C2000 easy to start with. Aside from low cost and modular development tools, we also have an open source developers package and a software suite that makes it easier than ever to access our libraries and frameworks.

## SLIDE 3:

**C2000(TM) optimized for real-time control applications**
C2000 is a strong fit in a variety of applications. And the common theme is precision sensing and control. Digital power need this for efficiency, motor control needs this for accuracy and efficiency as well, and lighting needs this for precise color mixing and intelligence. Automotive applications such as radar also needs precision sensing and control for quick reflexes and precise measurements. Renewable energy such as solar power inverters and wind power inverters need C2000 to provide the optimum amount of power back into the grid or to be used.

**C2000 32-bit MCU Roadmap (Public)**
C2000 was first introduced in 1997 with our 24X family based on a 16-bit core. Though we're still shipping in volume today, these devices are no longer recommended for new designs. In 2003 we debuted the C28X 32-bit core which is at the heart of all of today's C2000 devices. The first device is the feature of the C2000 include the F281X, F28OX and F282X series. You'll see these on the left here. The current generation of products include the Piccolo low cost high innovation series which is at the bottom, the Delfino floating point performance series at the top, and the Concerto multicore series at the very top featuring both the C28X and ARM Cortex M3 cores.

**C2000(TM) Piccolo(TM) Processors**
Piccolo currently has three product lines in production. The F28O2X provides low cost entry level products ranging from 40 megahertz the 60 megahertz with up to 64 kilobytes of Flash. The F28O3X line increases the Flash memory size to 128 kilobytes and also was the first family to include the control law accelerator for parallel control loop processing capabilities. The F28O6X brought floating point to Piccolo and built on top of F28O3X by adding USB device and host, the VCU for complex map processing and boosted RAM to 100 kilobytes and Flash to 256 kilobytes.

**C2000(TM) Delfino(TM) processors**
Delfino, our floating point performance line, has two high performance products. As one of the first affordable performance floating point MCUs, Delfino has been very popular in a variety of applications. The F28 3X line ranges from 100 to 150 megahertz and up to 512 kilobytes of Flash. The C2834X line offers double the performance at up to 300 megahertz but offers only RAM based solutions with up to 516 kilobytes of RAM.

**C2000(TM) Concerto(TM) processors**
A trend that we've seen with real-time control customers is the need to add communication along with real-time performance. And that's where Concerto comes in. In the past there's always been a compromise. Customers can pick a controller that is strong in control and sacrifice of communications, or pick a controller that's strong in communication but sacrifices on control. This is because control and communications have significantly different requirements for the core architecture. Another option was to simply buy two microcontrollers. But this can be expensive and complex. With Concerto, we've eliminated these compromises by combining both a real-time control core, the C28X, along with the communications core, the RM Cortex M3. In addition we've added new safety and security features as well as created a software infrastructure to make development easy.

**Control + Connectivity. No compromise.**
This is the block diagram of the super set Concerto MCU. You can see here that the device is nicely partitioned into a two subsystem device, one for real-time control and one for host communications. On the control side we

have the C28X core with floating point and all the related control oriented peripherals that are needed to execute complex algorithms needed for precise efficient power conversion, which is the essence of efficient motor control, renewable energy, and smart grid technologies. The host subsystem is based on the Cortex M3 and features the advanced connectivity peripherals for communications including Ethernet, USB on the go, dual CAN and multiple serial communication ports.

## SLIDE 9：

**C2000(TM) real-time controllers software**
The C2000 software ecosystem begins with a tool called Control Suite. Control Suite is a comprehensive and intuitive software suite designed to minimize software development. At its foundation are the device support packages. On each device customers can choose from three different levels of hardware abstraction that will allow them to program our microcontrollers their way. Then we have a library repository that not only has your standard math libraries but also has DSP libraries, application libraries, and utilities such as IQ Math which allows you to program floating point on fixed point nicrocontrollers. In addition we provide application libraries such as motor control software library and digital power library in order to create complete systems that can be taken and used in the real world. That's why we say Control Suite has real world solutions for real-time control. With Control Suite customers can spend less time on the basics and focus on differentiating their products. TI focuses not only on the contents od Control Suite but also and how it's delivered. All software is downloadable through a single smart installer. And when you select the device or kit that you want to evaluate, it will automatically take that into consideration and download the necessary software and dependencies. Best of all, Control Suite is completely free and comes with all the software source code, software schematics, and layout, so customers can take our systems and make it into their own.

## SLIDE 10：

**C2000 MCU Developer's Kits**
C2000's development kids are split into two kinds, device evaluation for simple and quick exploration of our device and features and application kits to explore some of our applications and see the device in action. Nearly all of these kits are based off of what we call a control card, which is a daughter card with a standard socket. This card features the C2000 device and all of the necessary support circuitry. With this card you can try different C2000 devices on our kits and easily replace it should something happen. The only exception to the control card concept is the control stick, which is a low cost tool that plugs right into the USB port on your computer. With integrated JTAG emulation and a set of break out pins, it's really all you need to get started all for under $40.

## SLIDE 11：

**Application Development Kits**
As mentioned earlier motor control, digital power, energy, and lighting, are some of our most prominent applications. That's why we have a variety of kits for each of these applications. These kits highlight some of the most popular and differentiated topologies amongst these applications. And they've been highly successful in the sense that they really bring out C2000's value and give our customers a huge head start in development. If you're familiar with these applications, you'll notice that these kits represent some of the most cutting edge technologies used by our customers today.