

QUESTIONS AND ANSWERS

Product-specific questions

Q. What are Piccolo MCUs?

A. TI introduced a new series of 32-bit TMS320C2000™ microcontrollers trademarked “Piccolo” in September 2008. This new series of C2000™ MCUs features architectural advancements, enhanced peripherals, on-chip analog and small package sizes to help bring real-time control and system management to applications typically unable to justify the associated cost. Piccolo controllers can replace multiple electronic components to lower overall systems cost while enabling advanced power electronics management.

The three key themes to keep in mind with respect to Piccolo MCUs are:

- Leading 32-bit performance for real-time control
- Lower system cost and ease of use
- MCU package and price

Q: Where did the name Piccolo come from?

A: TI named and trademarked TMS320F2802x/F2803x MCUs “Piccolo” to highlight the devices’ small size and low price.

Q. When will these products be available for sampling? In volume?

A:

- The first Piccolo devices, the TMS320F2802x series, sample December 15, 2008, offering 40-60MH performance, 32-64kB Flash and 38-48-pin configurations. Full volume production for the TMS320F2802x series is planned for September 2009.
- TMS320F2803x devices, offering 60MHz performance plus the new Control Law Accelerator (CLA) will be available for sampling during 1H09. F2803x devices offer 64-128KB Flash, 64-100-pin configurations and CAN, LIN and AECQ100 qualification. Full volume production for the TMS320F2803x series is planned for later in 2009.

Q. What is the pricing for these devices? Are they really under \$2?

A. Pricing for the Piccolo series of MCUs ranges from sub \$2 to \$8 over volume and configurations. Devices scale from 38-pins to 80-pins with various performance, peripheral and temperature mixes.

Q: Will TI offer even lower cost Piccolo devices in the future?

A: TI will continue to expand the Piccolo series of devices with configurations that will scale up and down the price/performance curve.

Q: Will future Piccolo devices be available in package sizes smaller than 38-pins?

A: Roadmap details are still being finalized, but TI will continue to investigate options that allow the Piccolo series to scale to smaller package sizes and target an even broader set of applications.

Q: What process technology is the Piccolo series of devices using?

A: The Piccolo MCU series is based on 180nm flash technology.

Q: What drove TI to bring the Piccolo MCUs to market?

A. TI's C2000 MCUs have done a great job over the years providing real-time control with up to 150 MIPS fixed point / 600 MFLOPS floating point performance along with the look and feel of an MCU. High-end applications have enjoyed the benefits of real time control for some time, but we've seen that our customers require this same level of performance, but at a scaled back price and package size. The new Piccolo devices help meet this need.

Additionally, we've seen a number of needs both from OEMs and end-customers that helped us understand what products would best suit today's changing market. These are summarized below.

End customers want →

Better efficiency
Enhanced features
Competitive pricing
Better technology sooner
Sleek form factor

OEMs need

Real time control
Increased processing power
Lower system cost
Ease of use
Small package size

Technology Questions

Q. When is real-time control required?

A. A real-time control system is one which not only depends on the logical correctness of the calculation but also requires that a result be made available within a specific time window to drive a result. Real-time control offers greater system efficiency and precision through the implementation of advanced algorithms and intelligent peripherals. The great thing about Piccolo MCUs is that they offer the benefits of real-time control with up to 60MHz processing power – along with a MCU package and price point.

Q: When would you need real-time control versus host control?

A: Dhrystone benchmarks show that an ARM-based controller such as the Cortex M3 is very well-suited for host-control, general purpose applications. However, real-time control incorporates significant math processing in addition to general purpose functions. TI's TMS320C28x real-time control MCUs provide a significant performance boost to real-time control systems through the significant math processing efficiency of the core.

Benchmark studies against Cortex M3 controllers reveal that Piccolo MCUs are:

- 30% faster for PID16 control algorithms
- 38% faster for PID32 control algorithms
- 2X faster for digital power (buck loop) cycles
- 4X faster for advanced control filter (FIR) tap

Q: What are the key enhancements that comprise Piccolo technology?

A: Piccolo devices offer a unique combination of performance and integration for real-time control. Some key features include:

- High-performance CPU with up to 60MH performance, single cycle 32-bit MAC, fast interrupt response and minimal latency.



- Control Law Accelerator: This new technology offers a 32-bit floating point math accelerator that operates independent of the C28x CPU that is designed to run complex, high-speed control algorithms and free the main CPU to handle I/O and feedback loop metrics resulting in up to 5 times increased performance for common control-loop applications.
- Intelligent architecture and peripherals:
 - Best in class PWM (EPWM) and event capture capability
 - 150-picosecond resolution on PWM frequency and duty cycle
 - High-accuracy on-chip oscillators (10MHz)
 - 12-bit fixed or ratio-metric ADC with individual channel triggers
 - Two analog comparators with 10-bit reference
 - Single 3.3V supply with BOR/POR supervision
 - Robust serial communication interfaces
 - Up to 22 general purpose I/Os

Q: Where can I find more information about the CLA?

A: The Microcontroller community forums has a great FAQ on the CLA. You can find the post here: <http://community.ti.com/forums/t/5394.aspx>. It also links to a Wiki article that dives deeper into the implementation of the CLA.

Q: How do these peripherals differentiate Piccolo technology?

A:

- TI's enhanced pulse width modulators (EPWM) support the industry's highest resolution with frequency modulation down to 150 pico-seconds to enable more control over harmonics and reduce sample-to-output delay – a critical factor in avoiding missing the falling edges of signals.
- Two on-chip oscillators operating at +/- 3 percent accuracy eliminate the need for external oscillators and their associated costs.
 - Many competitive microcontrollers offer only +/- 25 percent accuracy and/or integrate ring oscillators, which can have drift as high as 50 percent, rendering them unsuitable for reliably clocking communication interfaces.
 - The oscillators also offer triple-redundancy combined with on-chip self-test features to help designers achieve system-level safety certifications such as the IEC 60730 safety standard required for white goods in Europe.
- The ADC on Piccolo devices is a 12-bit, 13/16-channel ADC offering up to 4.6 MSPS. Competitive devices ADC typically offer only 1MSPs – a 4x difference.

Q: Will Piccolo MCUs or other C2000 devices offer on-chip USB?

A: TI is currently defining the next generation roadmap for C2000 controllers with definite interest in incorporating USB in the portfolio. Customer requirements and end application feedback will drive specifics on speed, performance and integration levels.

Q: How did TI push the cost down to sub-\$2 while still maintaining 32-bit real-time control?

A: The Piccolo MCU series is an efficient architecture that incorporates the right mix of control peripherals and on-chip resources to target the cost sensitive market. Not only is TI able to offer cost competitive device pricing, but we are also able to significantly reduce customers' system cost through our increased analog integration.



Q: What are some of the benefits of Piccolo devices' smaller package size?

A: Benefits include:

- Reduced board size (2-layer board instead of 4-layer) for lower system cost
- Increased reliability
- Lower cost/easier manufacturing – instead of having to use an X-Ray to inspect the devices, this inspection can be done visually.

Q: What other qualifications do these devices support?

A: AECQ100.

Tools / Software / Development

Q. What tools are available for Piccolo MCU-based devices?

A: Building on the controlCARD concept of removable target boards that plug into both general and application specific development and experimenters kits, TI is introducing a Piccolo MCU-based controlCARD on December 15, 2008 for just \$49. These low cost single board controllers are perfect for initial development and small volume systems. Analog I/O, digital I/O and JTAG signals are available with a DIMM interface.

There are also two new tools for developing with Piccolo microcontrollers: Piccolo controlSTICK and Piccolo Experimenter's Kit.

- **Piccolo controlSTICK (\$39):** The easiest way to evaluate Piccolo MCUs' advanced features, the Piccolo controlSTICK features onboard USB JTAG emulation, access to all control peripherals, simple example projects and a memory stick form factor.
- **Piccolo Experimenter Kit (\$79-\$89):** The new Piccolo Experimenter Kit features onboard USB JTAG emulation with no need for an external emulator. The kit includes the new baseboard with emulation, access to all device pins and a prototyping area. Also included is a Piccolo controlCARD (the \$49 F2802x controlCARD and \$59 F2803x controlCARD is also available for separate purchase). Using the same DIMM interface as previous controlCARDS, the new controlCARD is pin-for-pin compatible with existing controlCARDS, which are ideal for prototyping, limited production runs and reference designs.

Each kit includes a 32K code-limited version of TI's Code Composer Studio IDE, Gerber and hardware files and free application software. Other C2000 kits available include F2808 experimenter's kit (\$89), F28335 experimenter's kit (\$99), digital power experimenter's kit (\$229), DC/DC developer's kit (\$325), AD/DC developer's kit (\$695), resonant DC/DC kit (\$229), renewable energy kit (\$349). Future application-specific development boards planned include: appliance, audio, more generic motor control boards and additional digital power application boards.

Q: When should I order a controlSTICK v. an Experimenter's Kit?

A: The controlSTICK is an evaluation tool designed to teach users how to use Piccolo MCUs' advanced peripherals and become familiar with the devices. For development, the Experimenter's Kit and included controlCARD allow access to all device pins and rapid prototyping with the controlCARD.

Q: How do I order the controlSTICK or Experimenter's Kit?

A: All C2000 development kits, including the controlSTICK and Experimenter's Kit are available through the TI eStore (www.ti-eStore.com) or through distribution.



Q: Are controlSTICK example projects compatible with an Experimenter's Kit?

A: Yes. However, controlSTICK example projects are documented for the controlSTICK header pins and included hardware. Experimenter's Kit users will need to find the appropriate header pin on the docking station and make the necessary connections.

Q: How do you program these devices?

A: Similar to previous C2000 MCUs, the Piccolo series offers embedded Flash devices with various bootloader options to support programming.

Q: What kind of software support will you provide for Piccolo devices and tools?

A: For the controlSTICK, TI will release a package of example projects, which are short, simple programs designed to teach new users how to use Piccolo MCUs' peripherals. Each example project includes a user's guide and documented code.

The Piccolo Experimenter Kit includes an example project to show the framework that TI recommends when developing a project. TI will also provide the standard header files for Piccolo MCUs to help simplify the process of configuring peripherals. In addition, TI offers software libraries of pre-written digital power and motor specific algorithms available free at www.ti.com/c2000appsw as well as application-specific notes for the development and implementation of embedded control designs that cover most motor types as well as a variety of digital power applications: www.ti.com/mcappnotes.

Q: Are there plans to move to an Eclipse-based IDE for C2000 controllers?

A: TI is evaluating the Eclipse, open-source development environment for all microcontroller and DSP products. The product, Code Composer Studio v4, is planned for release in August 2009.

Applications

Q. What applications do the Piccolo MCUs target?

A. The four main markets Piccolo MCUs target include industrial, consumer, appliance and automotive applications. These are described in more detail below.

- **Industrial:** telecom/server rectifier; UPS, frequency inverters; AC drives; DC drives; Fan, blower, compressor, pump; power line communications;
- **Lighting:** LED street and building lighting, panel backlighting, automotive
- **Appliance:** air conditioners, washing machines, induction cooking, fridge compressors
- **Consumer:** AC/DC rectifier, power supply; LED backlighting; capacitive touch screen, electric toys
- **Automotive:** DC/DC control; hybrid vehicle, electric vehicle; electric power steering; battery management; LED/HID lighting; radar.

Q: Can you provide additional detail about Piccolo MCUs and solar micro-inverters?

A: Piccolo MCUs enable higher operating efficiency and control for solar panels. Typical systems use one inverter across multiple panels, and initial investigations have shown that individual or micro-inverters connected to each solar panel within a system can drive higher power conversion efficiencies. Micro-inverters maximize the output of each panel compared to system-wide inverters that maximize the output of panels.

Piccolo MCUs control the DC/DC conversion, DC/AC conversion and communication while the on-chip oscillator and VREG helps reduce external components. Digital control allows for component measurement and failure prediction, while on-chip peripherals (SPI, UART) simplify interfacing with other microcontrollers in the solar array. Piccolo MCUs also control the communication and solar inverter to allow direct system monitoring and reporting.



Q: How do Piccolo MCUs play into LED lighting?

A: Piccolo MCUs benefits LED lighting applications by:

- Offering intelligent current control
 - Automatic operating state (such as blowing a string) detection and protection
 - Temperature monitoring for thermal runaway prevention
- Providing precise operating voltage and current control for precise light intensity, color mixture/temperature control and increased efficiency
- Offering a uniform platform for different LED types or configurations
- Allowing for easy system networking – one Piccolo MCU can control LED lighting and the PLC communication system; DALI and other lighting control standards can be added easily; on-chip peripherals (SPI, UART) simplify interfacing with other systems.

Q: What are some of the benefits Piccolo MCUs can bring to an appliance application?

A: In a variable frequency air conditioning unit, for example, a single F2802x/F2803x controller can precisely control two electric three-phase motors as well as perform power factor corrections. Currently required in approximately 30% of the world's markets, PFC improves the efficiency of the load to make best use of power from the utility.

Questions related to other TI product lines

Q: You've talked a lot about digital power applications. How do these devices compare to TI's Analog digital power parts (a.k.a. "Fusion")

A: TI provides a broad portfolio of solutions that enable designers to implement digitally controlled power systems with high system intelligence and performance in an easy-to-use, intuitive development environment. C2000 controllers for digital power offer a solution for high performance, multi-channel digital power supply applications. HPA is bringing an array of power solutions to the market, including ones based off of F28x controllers. TI's digital power solutions are optimized for applications ranging from point-of-load to high-power AC/DC and DC/AC conversion

TMS320F28x controllers are the best fit when:

- Customer wants fully programmable solution
- Customer develops a scalable platform with multiple products
- Customer wants to develop differentiated topologies
 - Pin to pin compatible controllers
 - High-performance programmable CPU
 - System integration
 - High resolution PWM: 150ps

UCD9x devices are the best fit when:

- Customer wants to work with a GUI configurable application specific solution
- Customer needs solutions optimized for digital power
 - High performance AC/DC and DC/DC engine
 - Architecture minimizes need for external components
 - Supply currents as low as 4mA
 - Variety of package options: 32 to 80 pin

Q: Does TI have plans to announce a Cortex M3-based device?

A. TI will continue to invest in ARM-based processors, and is evaluating a variety of architectures, both proprietary and licensed IP, for future designs that best meet our customers' needs. TI has an established, successful history with ARM and is not only the most experienced manufacturer of ARM cores, but is also the largest shipper of these cores, having shipped a total of over 1 billion ARM-based cores. Several businesses in TI use ARM cores, including groups involved in automotive, wireless handsets (OMAP), IAG-imaging, video and DSP co-processors for telecommunications.

Q: Do C2000 controllers compete with TI's ARM-based MCUs? With MSP430 MCUs?

A. TI is a leading supplier of ARM-based products (from OMAP applications processors, to wireless processors, automotive devices and more) and we will continue to invest in that market. TI currently offers ARM-based controllers that are targeted towards general-purpose, host-control applications. However, C2000 controllers are ideally suited for applications that demand real-time control (see p. 2 for more information on real-time control).

For portable, battery-operated applications that require ultra-low power (down to 500 nano-amps in standby) and do not need real-time control functionality, TI's MSP430 microcontrollers are an excellent solution. MSP430 MCUs are the industry's lowest power MCUs and have a record of strong growth in a number of key applications (including e-metering and personal medical) as well as in the low power general purpose market. The MSP430 performs up to 25MHz and is a 16-bit MCU targeting both 8- and 16-bit applications.

Q: Are these three catalog MCU platforms compatible?

A: No. Each product line is designed to meet a specific set of design requirements and functionality. TI offers the industry's broadest portfolio of controller solutions to help customers manage embedded designs across a wide variety of applications. From ultra-low power and industry-standard processors to real-time control, TI microcontrollers meet the requirements of virtually any embedded design.

Q: TI has positioned itself as a DSP and Analog company for years. Why is it broadening its MCU focus?

A: Along with Intel, TI has been credited with inventing the MCU, and used MCUs in the first calculators invented. TI has been in the MCU business ever since it existed. TI has been a strong player in the MCU market for many years and is poised to continue to grow this business to address the rapid growth predicted in this sector.

MCU Nomenclature

Q. You've called C2000 a "digital signal controller" in the past - why?

A. Using "digital signal controller" to name TI's C2000 products highlighted the combination of real-time, control-focused silicon and microcontroller-like (MCU) design, combining the best of both worlds.

Q. Why is TI calling these new series of devices "MCU's"?

A. We've seen our customers demanding controllers that still offer advanced processing power, but in smaller footprints, more flash memory and integrated control peripherals common to a MCU. There has really been an evolution in the MCU market in which devices that provide advanced real-time control are beginning to look more and more like microcontrollers.



Q: How are you calling C2000 a microcontroller when the devices have a DSP core?

A: The great thing about the Piccolo series is that we have not changed or modified the CPU core with the release of this new series. We are seeing a market demand in the cost sensitive space that requires the CPU performance of the C28x core to handle intense math calculations and control algorithms with the look and feel of an MCU. The C2000 family brings the best of both worlds – providing a high performance CPU while incorporating the MCU features that the market is requesting such as embedded flash, ADCs, PWMs, capture, communication peripherals, comparators, and more.

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