

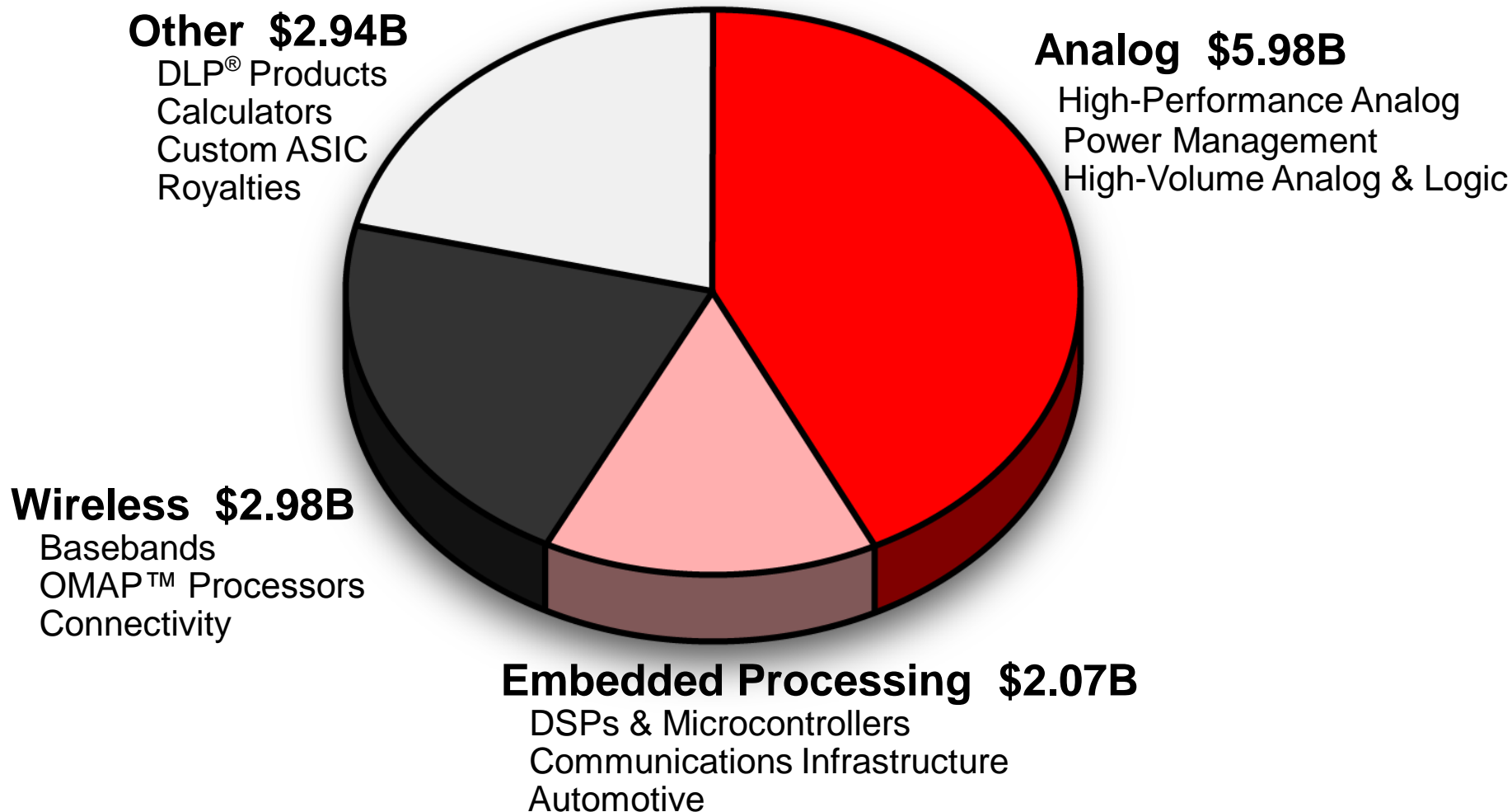
# C2000™ Regional Summit



November 2011

# Texas Instruments 2010 revenue by segment

**\$13.97B**



# C2000 Strategy: Remains EE Focused

## Renewable Energy



Solar Power Inverters

Wind Power Inverters



## Motor Control



White Goods



Industrial Drives & Motion Control



Pumps



E-bike

## Digital Power



Telecom / Server AC/DC Rectifiers



Uninterruptible Power Supplies



DC/DC Converters

C2000



LED Street Lighting



Auto HID



LED TV Backlighting

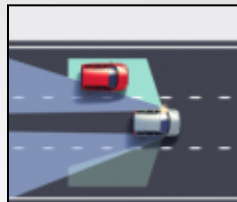
## Lighting

Hybrid Electric Vehicles



Electric Power Steering

Radar / Collision Avoidance

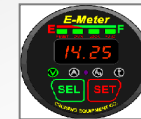


## Automotive



Power Line Communication

Smart Metering

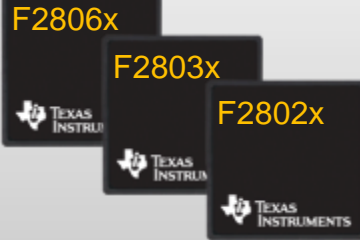


RF Communication

## Smart Grid & PLC

# Building Upon These 3 Brands

## Piccolo™ MCUs



### Performance:

40-80MHz 28x CPU  
Floating Point Unit (optional)  
CLA Co-Processor (optional)  
VCU Accelerator (optional)

### Memory:

16kB-128kB Flash  
6kB-100kB SRAM

### Key Peripherals:

ADC, PWM, QEP, DMA, SPI,  
UART, I2C, CAN, USB

### Package:

38 TSSOP, 48 QFP, 56 QFN, 64  
QFP, 80 QFP, 100 QFP



## Delfino™ MCUs



### Performance:

100-300MHz 28x CPU  
Floating Point Unit

### Memory:

Up to 512kB Flash  
Up to 516 kB SRAM

### Key Peripherals:

ADC, PWM, QEP, DMA, SPI, UART,  
I2C, CAN, EMIF

### Package:

176 QFP, 176 BGA, 179 u\*BGA,  
256 BGA



## Concerto™ MCUs



### Performance:

Dual Core  
Up to 150MHz 28x CPU  
Up to 100MHz ARM Cortex M3 CPU  
Floating Point Unit  
VCU Accelerator

### Memory:

256kB-1MB Flash  
Up to 132kB SRAM

### Key Peripherals:

ADC, PWM, QEP, DMA, EMIF, SPI,  
UART, I2C, CAN, USB, EMAC

### Package:

144 QFP



150+ Devices, Software Compatibility

# C2000 has a history of innovation

## Innovation for Power Electronics Applications



**F24x**  
**16-bit DSP**



**1995**  
Motor Control  
Applications  
Realize the  
Need of DSPs



**LF240x**  
**16-bit DSP**

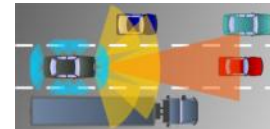
**1997**  
First Dedicated  
Device Aimed at  
Motor Control  
20 MHz, 10-bit ADC  
3PH PWM



**F281x/F280x**  
**32-bit MCU**

**2000**  
More Performance  
40 MHz, 10-bit ADC,  
3PH PWM

**2005**  
MCU Architecture  
Unified Memory  
150 MIPS  
12.5 MSPS 12-bit ADC  
High Res PWM,



**Delfino™**  
**32-bit FP MCU**


**2007**  
Highest  
Performance  
400-600  
MFLOPS,  
Floating Pt.



**Piccolo™**  
**32-bit MCU**

**2009**  
Lowest Cost!  
Low pin count!  
Differentiated  
Performance  
w/ CLA  
Vreg, BOR,  
POR, 3.3V,  
4.6 MSPS 12-  
bit ADC


# Connecting seamlessly to controlSUITE!




- controlSUITE
  - Devices
  - Kits
  - Libraries
  - Update
  - Datasheets and Guides
  - Application Notes
  - Training and Support
  - Developer Network
  - Code Composer Studio IDE
  - Search results

## Digital Power


HV AC/DC Bridgeless PFC Kit




HV AC/DC PFC Kit



HV DC/DC Phase Shifted Full Bridge Kit




HV DC/DC Resonant LLC Kit




And more....

## Energy & Lighting


Renewable Energy Kit



DC/DC Multi-string LED Kit



Multi-DC/DC Multi-string Color LED Kit



And more....

# Concerto Family

## 28x + ARM Cortex M3

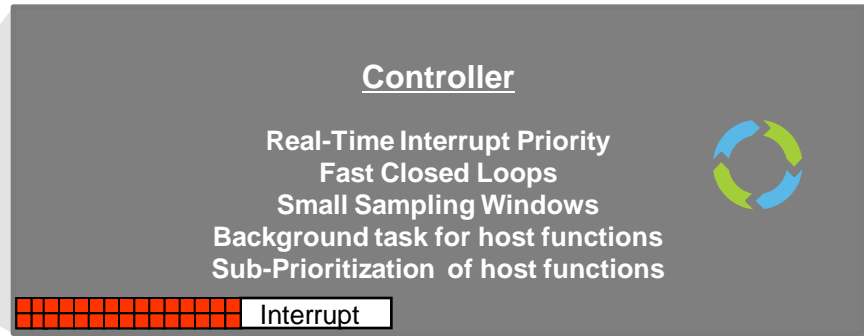


# Concerto™ MCUs eliminate compromise

## Standard MCU Challenge

- Compromise between ideal host and control capability

MCU

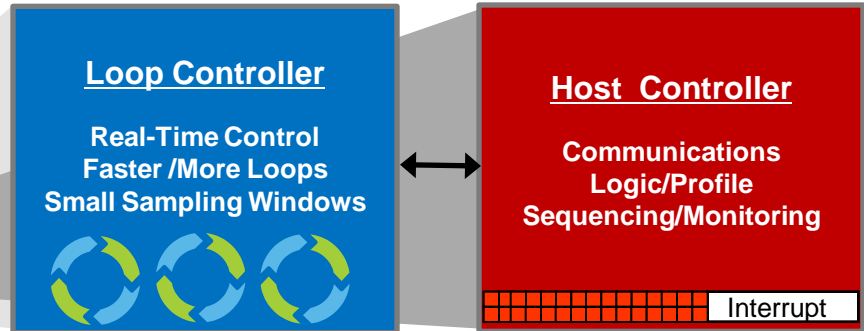


## Dedicated MCU Challenge

- Additional complexity
- Dual developments plus interface challenges / latency

MCU

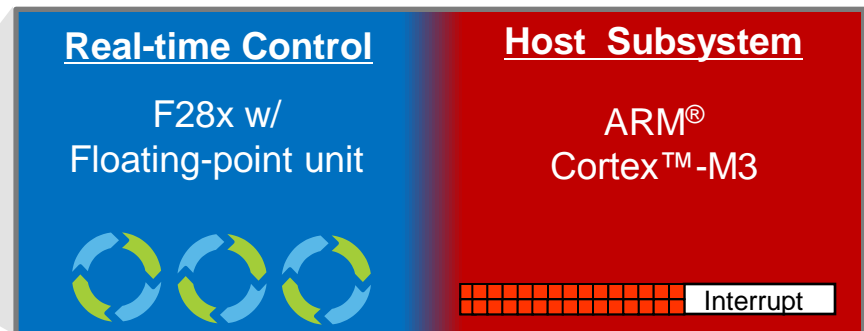
MCU



## Concerto Solution

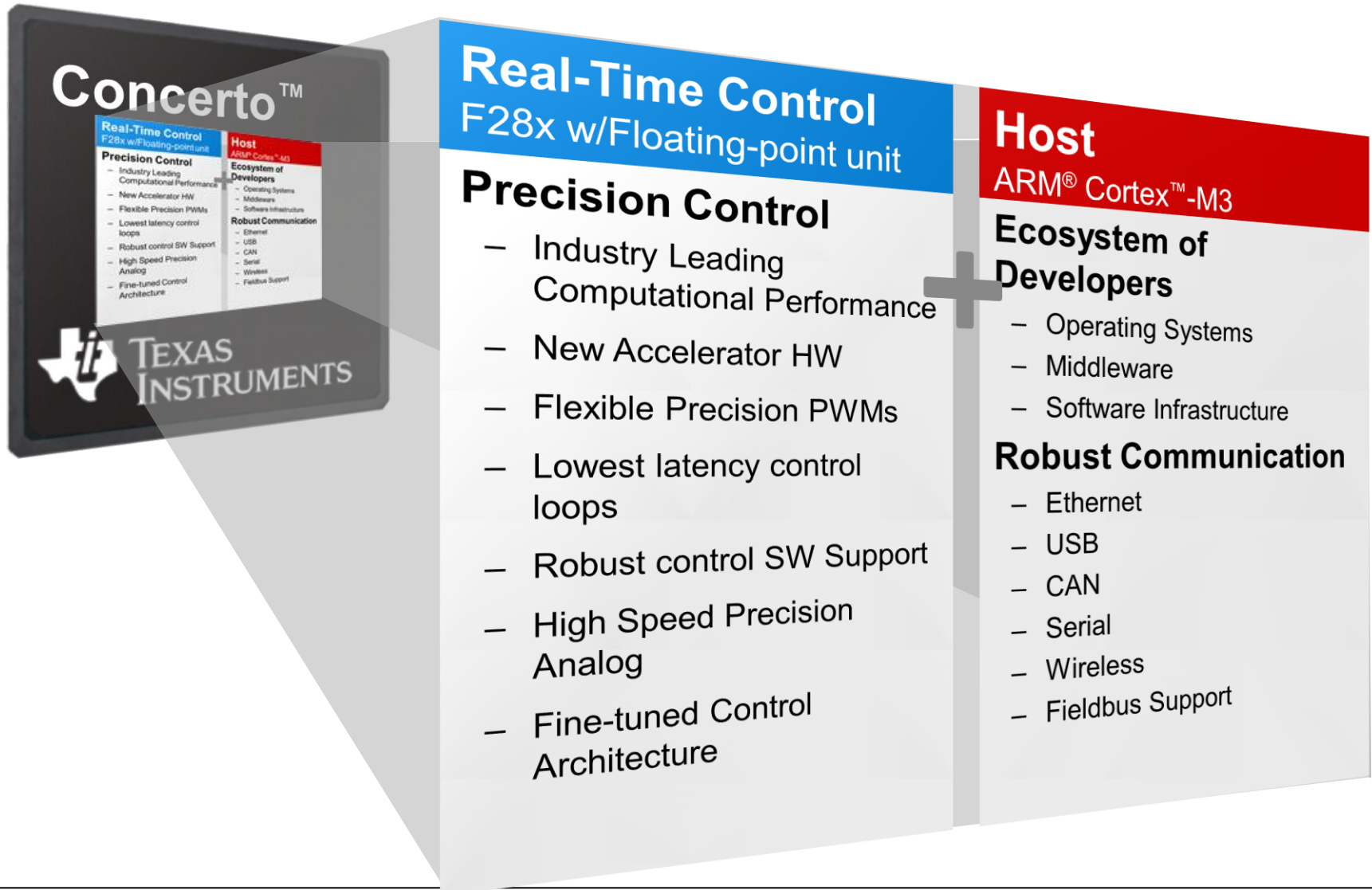
**No  
Compromises**

Concerto™





# Control + Connectivity. No compromise.



# No compromise means greener technologies



Industrial drives  
& automation

## Control

Multiple motors  
Torque & speed control  
Precision sensing

## Host

OS / RTOS  
Communication Bridge  
Motion Profile  
System management



Solar

## Control

Max power point tracking  
DC/DC boost  
DC/AC conversion

## Host

OS / RTOS  
Communication Bridge  
Supervisor  
System management



Server

## Control

Power conversion  
Multiple rails and loads  
Driving efficient  
topologies  
Power Protection

## Host

System management  
Load balancing  
Diagnostics

# Concerto Safety Features

## Error detection and correction

- Up to 1MB of 65nm Flash & 132K RAM with error correction (ECC)
- Parity on CAN and interrupt registers
- Cyclic Redundancy Checking (CRC)
- Comparators for over-current & over-voltage protection

## Redundancy for functions

- Two cores allow each core to check on the other to ensure accurate execution
- Two ADCs give ability to reliably monitor input measurements
- Two clocks for backup
- Multiple system watch dogs



## Security

- Lock protection on GPIO and registers
- Memory protection for software IP safeguarding
- Permanently disable JTAG for anti-theft protection

# Concerto™ ecosystem: controlSUITE™

Debug - spia\_loopback\_interrupts\_c28.c - Code Composer Studio (Licensed)

File Edit View Navigate Project Target Scripts Tools Window Help

Debug

Registers (2)

Core Registers

Name	Value
ACC	0xFFFFFFFF
P	0xFFFFFFFF
XT	0x00000000
XAR0	0x00000000
XAR1	0x0000FFFF
XAR2	0x00000000
XAR3	0x00000000
XAR4	0x00000000
XAR5	0x00000000
XAR6	0x00000000
XAR7	0x00000065
PC	0x0084A3
RPC	0x0085B7

```
79 //  
80 // Main body of the example  
81 //  
82  
83 void main(void)  
84 {  
85     Uint16 i;  
86 //  
87 // Step 1. Initialize the Control System:  
88 // WatchDog, enable peripheral clocks  
89 // This example function is found in the F28M35x_SysCtrl  
90 //  
91     InitSysCtrl();  
92  
93 // Step 2. Initialize GPIO:  
94 // This example function is found in the F28M35x_Gpio.c  
95 // illustrates how to set the GPIO to it's default state  
96 // this assumes the M3 has assigned the pins to the GPIO
```

Writable Smart Insert 35 : 1

28x Real-time while debugging M3

Debug - setup\_m3.c - Code Composer Studio (Licensed)

File Edit View Navigate Project Target Scripts Tools Window Help

Debug

Registers (2)

Core Registers

Name	Value
PC	0x2000013A
SP	0x2000013A
LR	0x2000013A
xPSR	0x60000000
R0	0x00000000
R1	0x00000000
R2	0x00000000
R3	0x00000000
R4	0x00000000
R5	0x00000000
R6	0x00000000
R7	0x2000013A
R8	0x00000000

```
29 #include "driverlib/cpu.h"  
30 #include "driverlib/gpio.h"  
31 #include "driverlib/gpio.c"  
32  
33 int  
34 main(void)  
35 {  
36     // Allow writes to protected registers.  
37     HWREG(SYSCTL_MWRALLOW) = 0xA5A5A5A5;  
38  
39     // Tells M3 Core the vector table is at the beginning  
40     HWREG(NVIC_VTABLE) = 0x20005000;  
41  
42     // Sets up PLL, M3 running at 75MHz and C28 running  
43     SysCtlClockConfigSet(SYSCTL_USE_PLL | SYSCTL_SPLLM  
44  
45     // Enable Peripherals  
46     SysCtlPeripheralEnable(SYSCTL_PERIPH_GPIOF);
```

LE

Breakpoints on one can cause break event on the other (cross-triggering)

# Piccolo Family

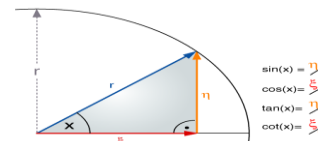


# Piccolo™ – Ever Increasing Differentiation

Performance, Memory, & Communications

F2807x  
Future

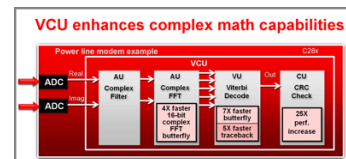
Enhanced Math  
Enhanced Control



- Trigonometric Math Unit
- Delta Sigma Modulators

F2806x

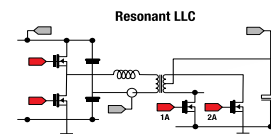
Floating Point &  
Communication



- 75 Added FPU Instructions
- 75 Added VCU Instructions
- USB Host

F2804x  
Future

Digital Power  
Enhancements



- Hi-Res PWMs (all channels)
- More Compare Registers
- Advanced Topology Support

F2805x  
Future

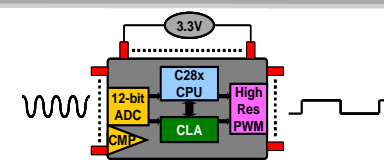
Motor Control  
Enhancements



- Op-Amps
- Motor IP (Insta-Spin)
- Window Comparators
- Quadrature Encoder

F2803x

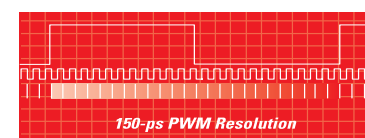
Co-Processor



- CLA – Control Law Accelerator
- Adds Performance

F2802x

Finer Control



- Hi-Res PWMs @ 150-ns
- PWM Resolution (select channels)
- Peak Current Control Mode

F2802x0

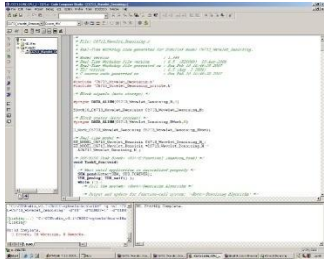
Piccolo Entry Line

28x DSP Core +  
Analog Integration + MCU  
Peripherals

# Development Tools

# C2000 Software Tools

## IDEs (compilers & debuggers)



**Code Composer Studio™**  
Eclipse-based Code Composer Studio™ IDE supports all TI embedded processors

- Unlimited with XDS100 emulator, else 32KB limit

IDE: Integrated Development Environment

## Modular Code Examples



controlSUITE™ provides modular software libraries for every design stage  
Other resources: [Technical Documents & User Guides](#)

## Stacks & Libraries

### Code Libraries

Math Libraries – IQMath for floating-point

DSP Libraries – Filter and FFT algorithms

Application Libraries – Digital Motor Control and Digital Power

Utilities – Flash API and Boot ROM Source Code

## SW Tools and Development Network

### controlSUITE™

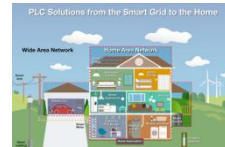


Comprehensive. Intuitive. Optimized. Real world software for real-time control. This cohesive set of software infrastructure and software tools is designed to minimize software development time. controlSUITE™ provides a centralized portal for all C2000 software, tools, documentation, and support.

#### Key Functional Areas

- Device Support (Bit fields, API Drivers)
- Library Repository (Math Library, DSP Library, Application Libraries, Utilities)
- Development Kit Support (Hardware Packages, Software Examples, Complete System Frameworks, Graphical User Interfaces)
- Debug and Software Tools (IDE, RTOS, Emulation)

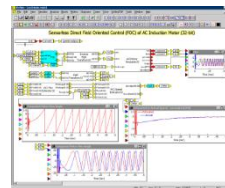
[www.ti.com/controlsuite](http://www.ti.com/controlsuite)



### PLCSuite

A modular software framework separating modulation, protocol and application development to extend the maximum flexibility to developers in testing and designing with PLC modems.

[www.ti.com/plc](http://www.ti.com/plc)



### Graphical Development & Code Gen. for C2000

Configure and debug C2000 applications with TI 3rd parties' GUI based code generation tools. Generated code from a graphical block diagram can be plugged-in for CCStudio ViSSim [www.vissim.com/c2000](http://www.vissim.com/c2000)  
Embedded Target [www.mathworks.com/products/tic2000](http://www.mathworks.com/products/tic2000)

### TI Partners

The C2000 development ecosystem features many other software tools, including Flash programming interfaces. Visit our partners page to see more:

[TI Partners Page](#)



# C2000 MCU Developer's Kits

## controlCARD



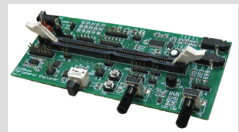
Unique daughter card which allows quick experimentation with different C2000 MCUs in application development and device evaluation kits. controlCARDS are all pin compatible, allowing easy experimentation with different C2000 MCUs.

## Device Evaluation



### Experimenter's Kits -

Docking station with access to controlCARD pins and prototyping area



### Peripheral Explorer Kits

Learning kit providing interaction with majority of C2000 device peripherals



### USB controlSTICKs

Quick and simple USB memory stick form factor device evaluation

## Application Development Kits

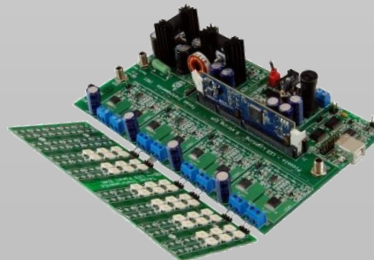
### Digital Power and Solar



### Digital Motor Control



### Lighting



C2000 offers a variety of hardware development tools designed to accelerate and simply the design process by providing real-world application examples.

### Kit Contents:

- controlCARD + Base Board
- Eclipse-based CCStudio IDE
- Example Software with System Guides
- Power Supply and Cables

### Developer's Packages:

- Schematics (source, .PDF files)
- Bill of materials (BOM)
- Gerber files to freely use or modify
- Pin-out table showing all key signals
- DIMM100 pin/socket mechanical details
- Available for free in controlSUITE™

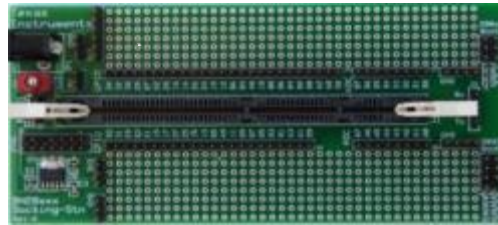
### controlSUITE™

Centralized portal for C2000 device and development kit software, documentation, and support.

# Experimenter's Kits Device Evaluation

## Kits Include

- Docking Station
  - Prototyping Area
  - Access to most controlCARD signals
  - 5V and 3.3V rails
- controlCARD
  - F2808
  - F28335
  - F28027
  - F28035
  - F28069 **NEW!**
  - C28345
  - C28346
  - F28M35H52C1 **NEW!**
- Code Composer Studio V4
- Full hardware documentation
- Example projects



- Delfino C28343  
TMDXDOCK28343 - \$159



- Delfino DIM168 C28346  
TMDXDOCK28346-168 - \$189



External JTAG emulator required

- F2808 TMDSDOCK2808 - \$89



- Delfino F28335 TMDSDOCK28335 - \$99



- Piccolo F28027 TMDSDOCK28027 - \$79



- Piccolo F28035 TMDSDOCK28035 - \$89



- Piccolo F28069 TMDSDOCK28035 - \$99



**NEW!**

- Concerto F28M35 TMDSDOCKH52C1 - \$139



**NEW!**

Includes onboard USB JTAG emulation

# Concerto Development Tools

## H52C1 controlCARD - \$99

Plug-and-play with any existing DIM100 controlCARD-based development kit

- Includes Ethernet, microSD, and microUSB OTG ports
- JTAG emulation on-board via USB
- Orderable part number: TMDXCNCDDH52C1



## H52C1 Experimenter Kit - \$139

controlCARD and prototyping area in one kit

- Includes the Concerto DIM100 controlCARD, docking station, and cables
- Orderable part number: TMDXDOCKH52C1



# Application Development Kits

## Motor Control



HV Motor & PFC Kit



Multi-Axis & PFC Kit



Brushed and Stepper Motor Control



3-phase Brushless Motor Control

And more....

## Digital Power



HV AC/DC Bridgeless PFC Kit



HV AC/DC PFC Kit



HV DC/DC Phase Shifted Full Bridge Kit



HV DC/DC Resonant LLC Kit

And more....

## Energy & Lighting



Renewable Energy Kit



DC/DC Multi-string LED Kit



Multi-DC/DC Multi-string Color LED Kit

And more....