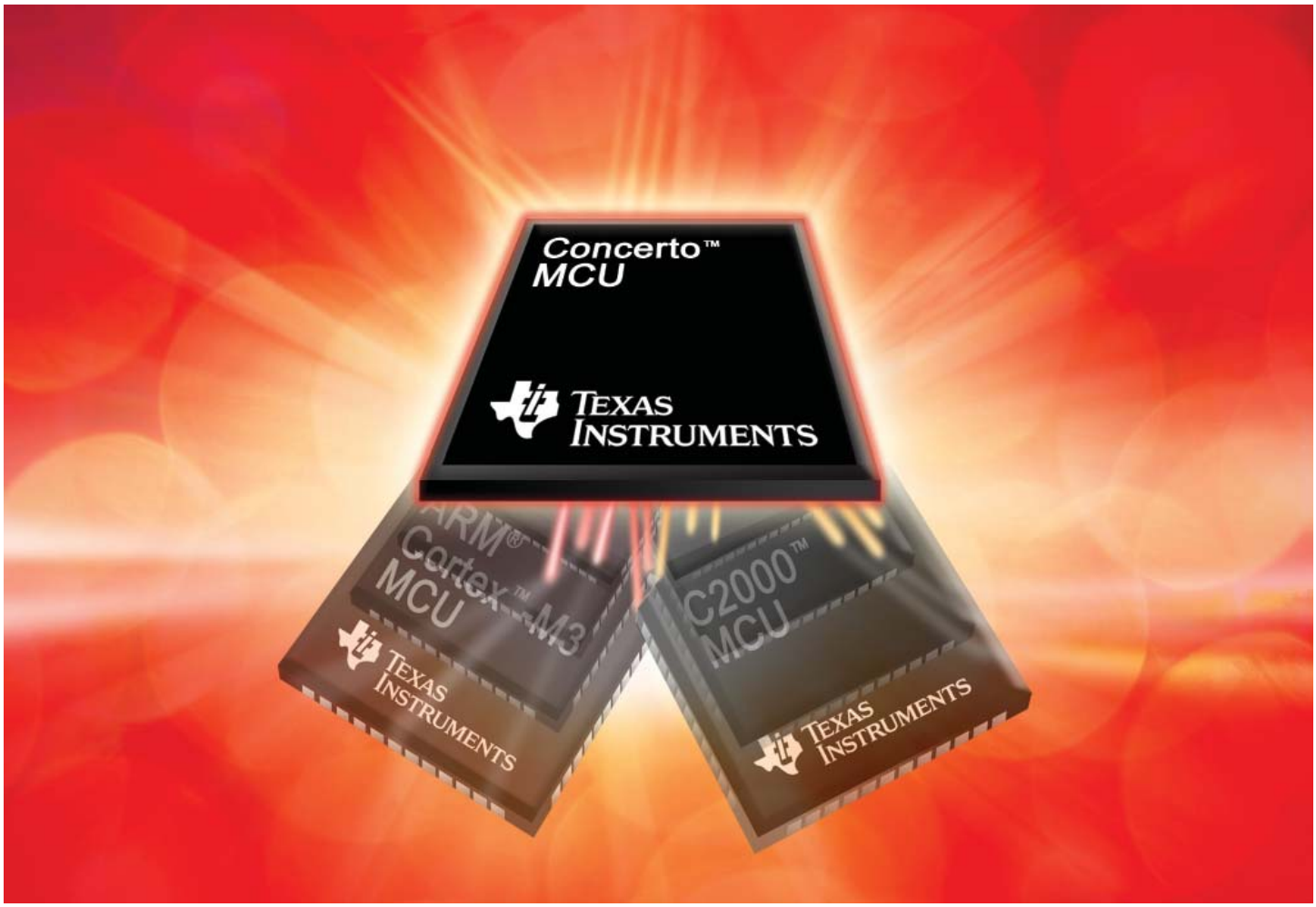
C2000™ Concerto™ Microcontrollers

Texas Instruments



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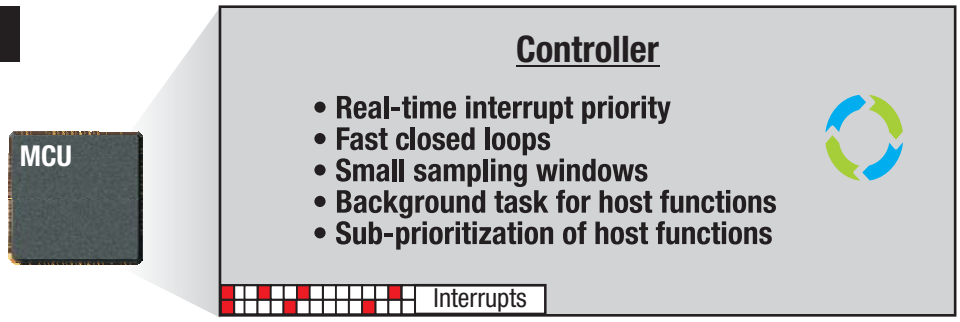
www.ti.com/concerto

Control or communications? Why compromise?

Engineering is full of compromises. It's a balance between numerous aspects – cost, power consumption, reliability, feature set, flexibility, and the list goes on. With every generation, engineers push the envelope of efficiency and functionality in their designs. Digital control is bringing new possibilities in driving smarter and more efficient systems. Connectivity is becoming pervasive in applications that previously didn't require communication. Today, in many real-time control applications, such as automation or energy conversion, one of the biggest compromises is finding a balance between robust loop control and adding communications or host functionality. But what if you could eliminate some of those compromises?

Standard MCU Challenge

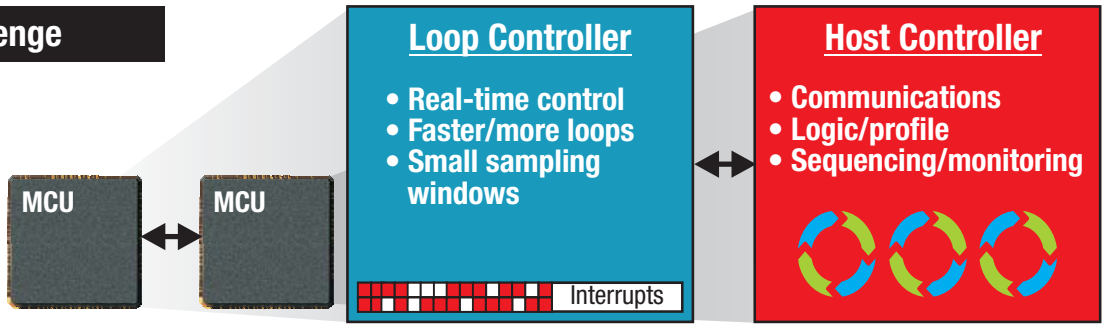
- Compromise between ideal host and control capability



In the past, there were two solutions to this problem. The first, in cost-sensitive applications, was to select one MCU that would perform both control and communications functions. From a hardware standpoint, it's a simple solution, but often requires a compromise on features and performance. In addition, software becomes more difficult as tasks and interrupts must be prioritized properly.

Classic Control Challenge

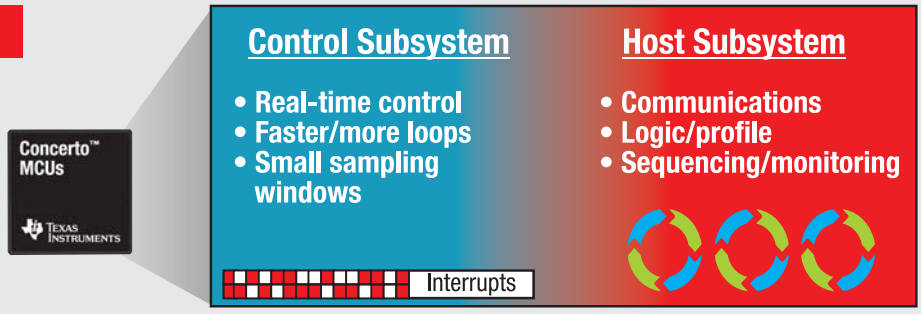
- Additional complexity
- Dual developments plus interface challenges/latency



A second solution is to use two microcontrollers – a host microcontroller taking care of communications, monitoring, and other system functions while a second loop microcontroller focuses on the real-time control aspect. This solution provides clean partitioning, but adds cost, complexity, and latency from communication between the two controllers.

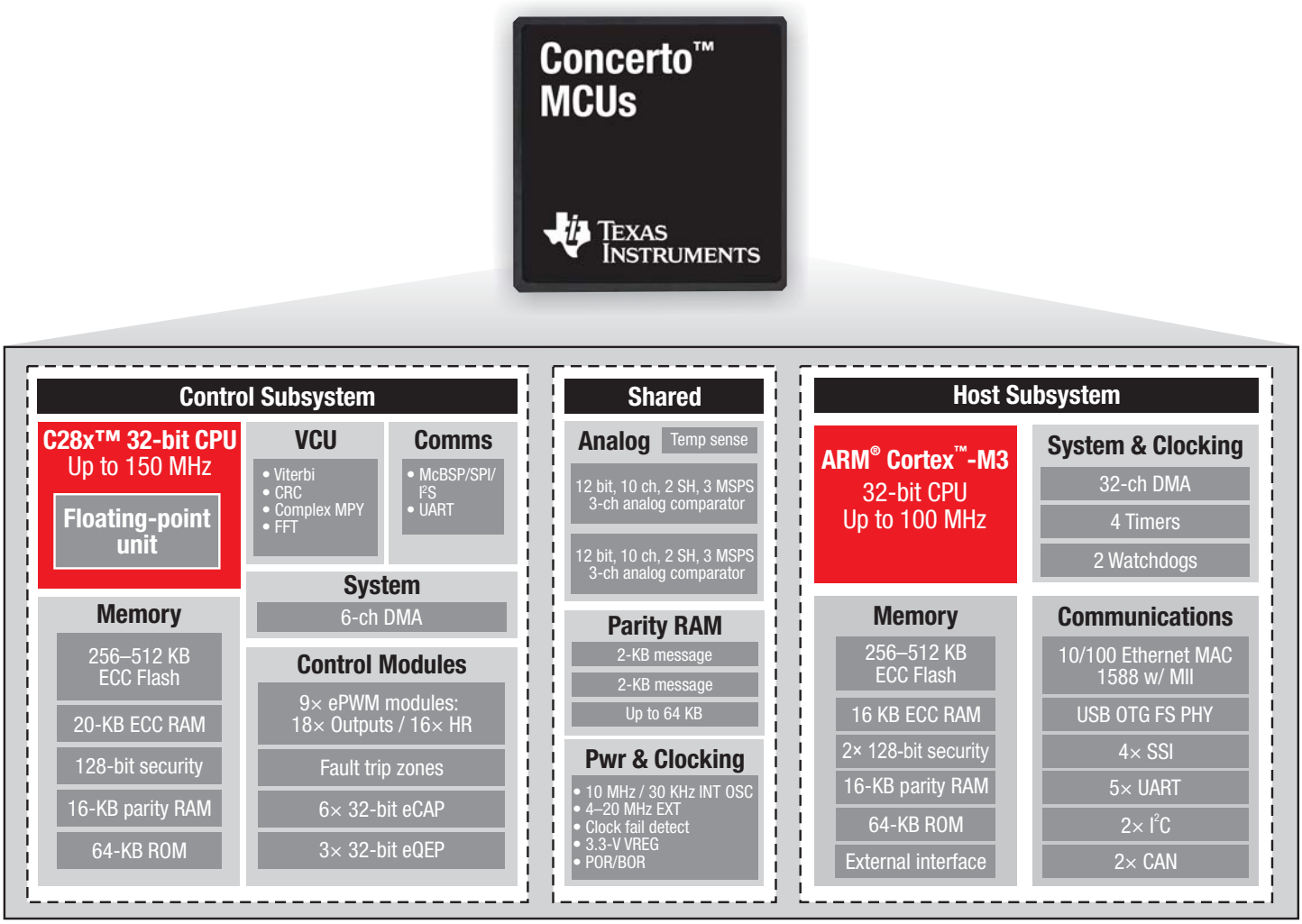
Concerto™ MCU Solution

- Optimized subsystems
- Single-chip solution reduces complexity
- Faster interprocessor communication reduces latency



With the C2000 Concerto™ family of microcontrollers, the need to compromise is eliminated. By combining an industry-leading Host core along with an industry-leading control core, Concerto MCUs provide the best of both worlds in one device, simplifying both hardware and software aspects, all while reducing cost.

Introducing Concerto™ MCUs: Connectivity without compromise



Real-Time Control
TI 32-bit F28x with FPU

Processing and control
- Industry leading computational performance
- Lowest control loop latency
- Robust control software support
- Fine-tuned control architecture

Precision peripherals
- Flexible, highest resolution, best synchronization PWMs
- High-speed precision-synchronized analog
- Flexible power line modem solution

Industry's #1 MCU for power electronics and power-line modem

+

Host MCU
ARM® 32-bit Cortex™-M3

Ecosystem
- Operating systems
- Middleware
- Software infrastructure

Rich Communications
- Ethernet
- USB
- CAN, serials
- Wireless
- Various field busses

Application Layer
- Sequencing, profiles
- Diagnostics, monitoring

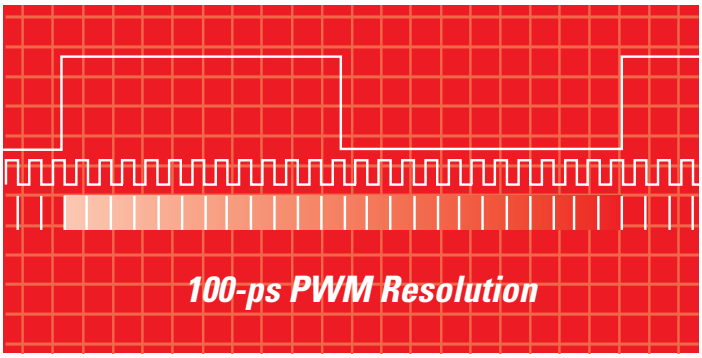
Industry's #1 MCU for general purpose and communication

Concerto™ MCUs: Best of both worlds

With both host and control subsystems on one device, Concerto MCUs bring you the best of both worlds:

C28x Core (control):

- Up to 150 MHz with floating point
- Sensing and DSP filtering and processing
- Firmware programmable power line modem solutions
- PWMs with unmatched flexibility, programmability, and resolution (down to 100 picoseconds)
- Enhanced Quadrature Encoder interface (eQEP) is compatible with almost any linear or rotary encoder for motor control applications
- Enhanced capture for precision in applications like radar and ultra-sonic sensing



ARM® Cortex™-M3 (host):

- Up to 100 MHz
- Take advantage of Cortex-M3's rich ecosystem
- Optimized for host communications

Shared / System:

- Up to 1MB of 65-nm Flash and 132K RAM
- Dual 12-bit ADC, 3 MSPS and 2 sample-and-holds each, 20 channels. Unique start-of-conversion triggering for intelligent sampling.
- Error detection and correction on Flash and RAM sectors
- Redundancy for safety
  - Two independent cores with monitoring
  - Dual ADCs for speed and reliability
  - Built-in clock monitoring with multiple system watch dogs
- Security features for memory protection
- Inter-processing communications library for simple, no-lag information transfer between subsystems
- On-chip analog comparators for instantaneous over-current/over-voltage protection
- Even more integration to simplify hardware design
  - Integrated high-speed oscillator and real-time clock
  - On-chip POR/BOR
  - Single-rail supply, on-chip voltage regulator
- Automotive Q100

Focus on differentiation

Concerto MCUs allow engineers to leverage easy-to-use software and application libraries from the C2000™ controlSUITE™ software platform as well as ARM Cortex-M3's ecosystem, resulting in an unparalleled environment of software and support. Previous developments on C2000 can be ported to Concerto. MCUs

- Scalability between the entire C2000 portfolio – from 40 MHz to 300 MHz
- Single IDE built in functionality with dual core debugging and programming
- Multi-OS support
- controlSUITE software
  - 40+ man years of application software libraries and device drivers
  - Plethora of libraries - communication stacks (USB, Ethernet) motor control, digital power, power line communication
  - Application kit software and hardware completely open source, including schematics, bill of materials, even layouts

controlSUITE: C2000 C28x

- Header file library
  - Allows for bit-field register access or driver-based functions
- Math, DSP libraries for both fixed and floating point
- Application libraries (motor control, digital power, and more!)
- Code examples and utilities
- SYSBIOS from TI
- Complete source code available, free license and royalty-free use

controlSUITE: ARM Cortex-M3

- Peripheral driver library
  - Allows for direct register access or driver-based functions
- Display, graphics library
- Code examples
- In-system programming support
- CMSIS hardware abstraction
- Complete source code available, free license and royalty-free use

Concerto™ MCU applications and benefits

With Concerto MCUs, a variety of applications can benefit from separate host and control subsystems.

Industrial automation

Host
OS / RTOS
Communication bridge
Motion profile
System management

Control
Multiple motors
Torque and speed control
Precision sensing

Benefits

- Host subsystem takes care of communication and system management without being sidetracked by strict control loop interrupts
- Control subsystem is not burdened by communication, more bandwidth for custom control algorithms and multi-axis control
- Industry-leading PWMs for precision motor control
- On-chip comparators for over-current and over-voltage detection to protect equipment

Solar farms

Host
OS / RTOS
Communication bridge
Diagnostics
System management

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

Benefits

- Host subsystem takes care of diagnostics and management
- Control subsystem optimized for maximum power point tracking algorithms
- Integrate power tracking along with power conversion
- Enable smart switching between grid connection and battery systems
- Programmable for any power line communications protocol

Server farms

Host
Load balancing
Diagnostics
System management

Control
Power conversion
Multiple rails and loads
Driving efficient topologies
UPS

Benefits

- Host subsystem takes care of communication, load balancing, and more
- Control subsystem can focus on digital power techniques for higher efficiency, increased reliability
- Programmable control subsystem allows for increased scalability between power rating levels and topologies
- Instantaneously detect power irregularities and switch to UPS backup systems

Concerto™ MCU parts list

	Processor				Memory		Control Interfaces									Communication Ports							Other					
Part Number	Speed (MHz) C28x/CM3	FPU	VCU	DMA	RAM (KB)	Flash (KB)	PWM Chs*	HR PWM	Timers	Event Cap-tures	QEP/ QEI	ADC Resolution	ADC Inputs	ADC MSPS	Compa-rators	USB (OTG)	ENET	SPI	SCI	CAN	I²C	McBSP	0-Pin OSCs	I/O Pins	I/O / Supply Voltage (V)	Packaging	Ext. Temp (-40 to 125°C)	10kU SRP (U.S. $)
5-Series: Entry																												
F28M35E20B	60/60	Yes	Yes	Yes	72	512	24	16	25	6	3	2× 12-bit	20	4.6	6	–	–	5	6	2	3	1	2	64	3.3/3.3	144 HTQFP	Yes	6.71
F28M35E20C	60/60	Yes	Yes	Yes	72	512	24	16	25	6	3	2× 12-bit	20	4.6	6	1	Yes	5	6	2	3	1	2	64	3.3/3.3	144 HTQFP	Yes	8.15
F28M35E22B	60/60	Yes	Yes	Yes	136	512	24	16	25	6	3	2× 12-bit	20	4.6	6	–	–	5	6	2	3	1	2	64	3.3/3.3	144 HTQFP	Yes	8.64
F28M35E22C	60/60	Yes	Yes	Yes	136	512	24	16	25	6	3	2× 12-bit	20	4.6	6	1	Yes	5	6	2	3	1	2	64	3.3/3.3	144 HTQFP	Yes	10.08
F28M35E32B	60/60	Yes	Yes	Yes	136	768	24	16	25	6	3	2× 12-bit	20	4.6	6	–	–	5	6	2	3	1	2	64	3.3/3.3	144 HTQFP	Yes	9.26
F28M35E32C	60/60	Yes	Yes	Yes	136	768	24	16	25	6	3	2× 12-bit	20	4.6	6	1	Yes	5	6	2	3	1	2	64	3.3/3.3	144 HTQFP	Yes	10.70
F28M35E50B	60/60	Yes	Yes	Yes	72	1024	24	16	25	6	3	2× 12-bit	20	4.6	6	–	–	5	6	2	3	1	2	64	3.3/3.3	144 HTQFP	Yes	8.88
F28M35E50C	60/60	Yes	Yes	Yes	72	1024	24	16	25	6	3	2× 12-bit	20	4.6	6	1	Yes	5	6	2	3	1	2	64	3.3/3.3	144 HTQFP	Yes	10.32
F28M35E52B	60/60	Yes	Yes	Yes	136	1024	24	16	25	6	3	2× 12-bit	20	4.6	6	–	–	5	6	2	3	1	2	64	3.3/3.3	144 HTQFP	Yes	9.84
F28M35E52C	60/60	Yes	Yes	Yes	136	1024	24	16	25	6	3	2× 12-bit	20	4.6	6	1	Yes	5	6	2	3	1	2	64	3.3/3.3	144 HTQFP	Yes	11.28
5-Series: Mid-end																												
F28M35M20B	75/75	Yes	Yes	Yes	72	512	24	16	25	6	3	2× 12-bit	20	5.8	6	–	–	5	6	2	3	1	2	64	3.3/3.3	144 HTQFP	Yes	9.12
F28M35M20C	75/75	Yes	Yes	Yes	72	512	24	16	25	6	3	2× 12-bit	20	5.8	6	1	Yes	5	6	2	3	1	2	64	3.3/3.3	144 HTQFP	Yes	10.56
F28M35M22B	75/75	Yes	Yes	Yes	136	512	24	16	25	6	3	2× 12-bit	20	5.8	6	–	–	5	6	2	3	1	2	64	3.3/3.3	144 HTQFP	Yes	10.08
F28M35M22C	75/75	Yes	Yes	Yes	136	512	24	16	25	6	3	2× 12-bit	20	5.8	6	1	Yes	5	6	2	3	1	2	64	3.3/3.3	144 HTQFP	Yes	11.52
F28M35M32B	75/75	Yes	Yes	Yes	136	768	24	16	25	6	3	2× 12-bit	20	5.8	6	–	–	5	6	2	3	1	2	64	3.3/3.3	144 HTQFP	Yes	10.70
F28M35M32C	75/75	Yes	Yes	Yes	136	768	24	16	25	6	3	2× 12-bit	20	5.8	6	1	Yes	5	6	2	3	1	2	64	3.3/3.3	144 HTQFP	Yes	12.14
F28M35M50B	75/75	Yes	Yes	Yes	72	1024	24	16	25	6	3	2× 12-bit	20	5.8	6	–	–	5	6	2	3	1	2	64	3.3/3.3	144 HTQFP	Yes	10.32
F28M35M50C	75/75	Yes	Yes	Yes	72	1024	24	16	25	6	3	2× 12-bit	20	5.8	6	1	Yes	5	6	2	3	1	2	64	3.3/3.3	144 HTQFP	Yes	11.76
F28M35M52B	75/75	Yes	Yes	Yes	136	1024	24	16	25	6	3	2× 12-bit	20	5.8	6	–	–	5	6	2	3	1	2	64	3.3/3.3	144 HTQFP	Yes	11.28
F28M35M52C	75/75	Yes	Yes	Yes	136	1024	24	16	25	6	3	2× 12-bit	20	5.8	6	1	Yes	5	6	2	3	1	2	64	3.3/3.3	144 HTQFP	Yes	12.72
5-Series: High-end																												
F28M35H20B	150/75 or 100/100	Yes	Yes	Yes	72	512	24	16	25	6	3	2× 12-bit	20	5.8	6	–	–	5	6	2	3	1	2	64	3.3/3.3	144 HTQFP	Yes	11.76
F28M35H20C	150/75 or 100/100	Yes	Yes	Yes	72	512	24	16	25	6	3	2× 12-bit	20	5.8	6	1	Yes	5	6	2	3	1	2	64	3.3/3.3	144 HTQFP	Yes	13.20
F28M35H22B	150/75 or 100/100	Yes	Yes	Yes	136	512	24	16	25	6	3	2× 12-bit	20	5.8	6	–	–	5	6	2	3	1	2	64	3.3/3.3	144 HTQFP	Yes	12.72
F28M35H22C	150/75 or 100/100	Yes	Yes	Yes	136	512	24	16	25	6	3	2× 12-bit	20	5.8	6	1	Yes	5	6	2	3	1	2	64	3.3/3.3	144 HTQFP	Yes	14.16
F28M35H32B	150/75 or 100/100	Yes	Yes	Yes	136	768	24	16	25	6	3	2× 12-bitt	20	5.8	6	–	–	5	6	2	3	1	2	64	3.3/3.3	144 HTQFP	Yes	13.34
F28M35H32C	150/75 or 100/100	Yes	Yes	Yes	136	768	24	16	25	6	3	2× 12-bit	20	5.8	6	1	Yes	5	6	2	3	1	2	64	3.3/3.3	144 HTQFP	Yes	14.78
F28M35H50B	150/75 or 100/100	Yes	Yes	Yes	72	1024	24	16	25	6	3	2× 12-bit	20	5.8	6	–	–	5	6	2	3	1	2	64	3.3/3.3	144 HTQFP	Yes	12.96
F28M35H50C	150/75 or 100/100	Yes	Yes	Yes	72	1024	24	16	25	6	3	2× 12-bit	20	5.8	6	1	Yes	5	6	2	3	1	2	64	3.3/3.3	144 HTQFP	Yes	14.40
F28M35H52B	150/75 or 100/100	Yes	Yes	Yes	136	1024	24	16	25	6	3	2× 12-bit	20	5.8	6	–	–	5	6	2	3	1	2	64	3.3/3.3	144 HTQFP	Yes	13.92
F28M35H52C	150/75 or 100/100	Yes	Yes	Yes	136	1024	24	16	25	6	3	2× 12-bit	20	5.8	6	1	Yes	5	6	2	3	1	2	64	3.3/3.3	144 HTQFP	Yes	15.36

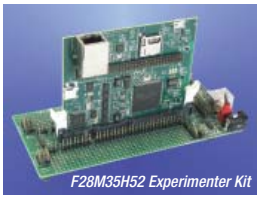
All devices include one 2-pin oscillator and POR/BOR.
**PWM channels include output from ePWM modules (2 per module) and eCAP. The eCAP can be configured as a PWM when not used for capture.*

Development tools

Concerto tools will continue the C2000™ controlCARD tools methodology. By detaching the C2000 processor and all necessary support circuitry and putting them on controlCARDs, a designer can test multiple processors on one application board. These controlCARDs require only one 5-V supply and plug into a simple motherboard connector that gives access to every pin on the device. All C2000 application kits are also based on controlCARDs

Start exploring what Concerto MCUs have to offer, right out of the box!

Part number	Description	Price
TMDXCNCDH52C1	F28M35H52 controlCARD	$130.00
TMDXDOCKH52C1	F28M35H52 Experimenter Kit	$185.00


F28M35H52 Experimenter Kit


F28M335H52 controlCard

Printed in U.S.A. by Etheridge Printing Company, Dallas, TX

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Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265