

MSP430 Ultra-Low-Power MCUs

2004



Key Features

- Ultra-low-power architecture extends battery life:
 - 0.1 μ A RAM retention
 - 0.8 μ A real-time clock mode
 - 250 μ A/MIPS active
- High-performance analog ideal for precise measurement
- Modern 16-bit RISC CPU enables new applications at a fraction of the code size
- In-system programmable Flash permits flexible code changes, field upgrades and data logging
- Complete integrated development environment starting at \$49
- Device pricing as low as \$0.49

Key Applications

- Utility metering
- Portable instrumentation
- Intelligent sensing

MSP430 Architecture

A 16-bit RISC CPU, peripherals and flexible clock system are combined by using a von-Neumann common memory address bus (MAB) and memory data bus (MDB). Partnering a modern CPU with modular memory-mapped analog and digital peripherals, the MSP430 offers solutions for today's and tomorrow's mixed-signal applications.

Memory Options

- Flash, ROM, OTP versions (from 1 KB to 60 KB)
- RAM up to 10 KB

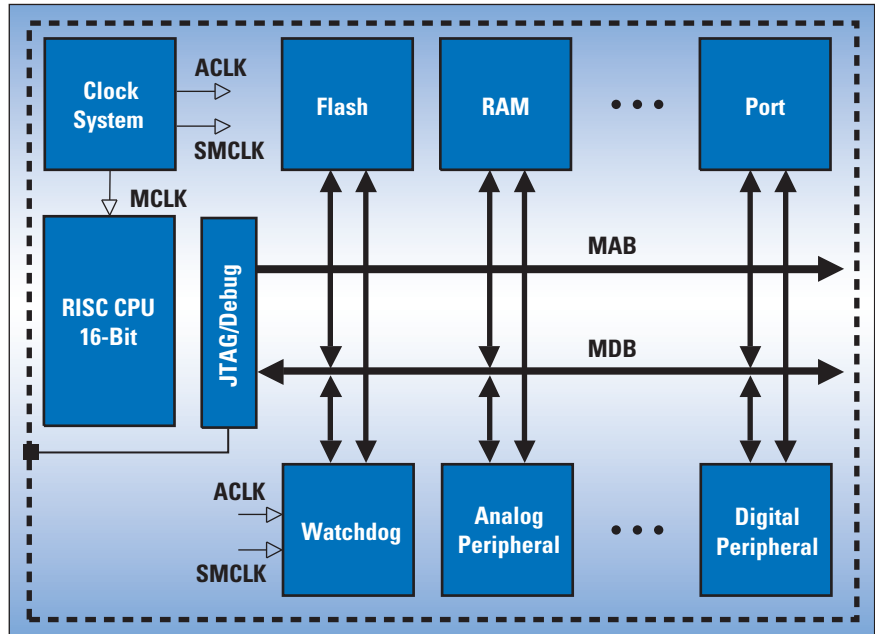
Analog Peripherals

- High-performance ADC
- Dual DACs
- Comparator
- LCD driver
- Supply Voltage Supervisor (SVS)
- Operational amplifiers

Digital Peripherals

- USART/I²C
- Hardware multiplier
- 16-bit and 8-bit timers
- DMA controller

Modular Architecture



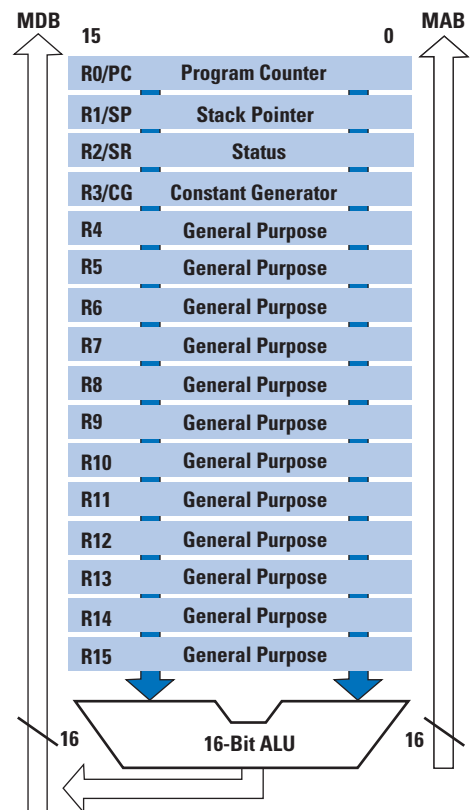
MSP430 von-Neumann architecture — all program, data memory and peripherals share a common bus structure. Consistent CPU instructions and addressing modes are used.

Modern 16-Bit RISC CPU

- Large register file eliminates accumulator bottleneck
- Optimized for C and assembler programming
- Compact core design reduces power and cost
- Up to 8 MIPS of performance available

The MSP430's orthogonal architecture provides the flexibility of 16 fully addressable, single-cycle 16-bit CPU registers and the power of a RISC. The modern design of the CPU offers versatility through simplicity using only 27 easy-to-understand instructions and seven consistent-addressing modes. This results in a 16-bit low-power CPU that has more effective processing, is smaller-sized, and more code-efficient than other 8-/16-bit microcontrollers. Now it's possible to develop new ultra-low-power, high-performance applications at a fraction of the code size.

MSP430 Modern Orthogonal 16-Bit RISC CPU



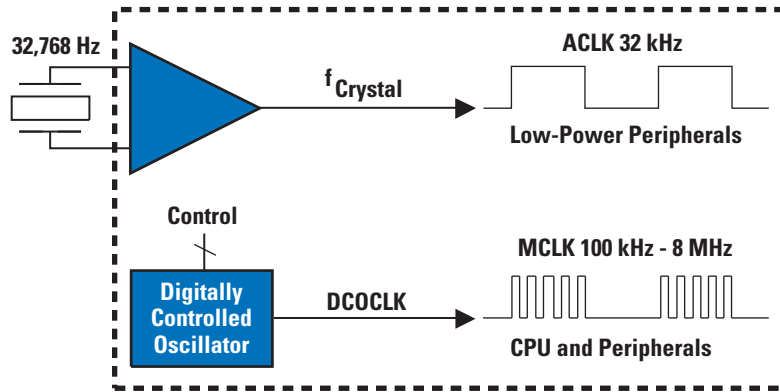
The MSP430 CPU core with sixteen 16-bit registers, 27 single-cycle instructions and seven addressing modes results in higher processing efficiency and code density.

Flexible Clock System

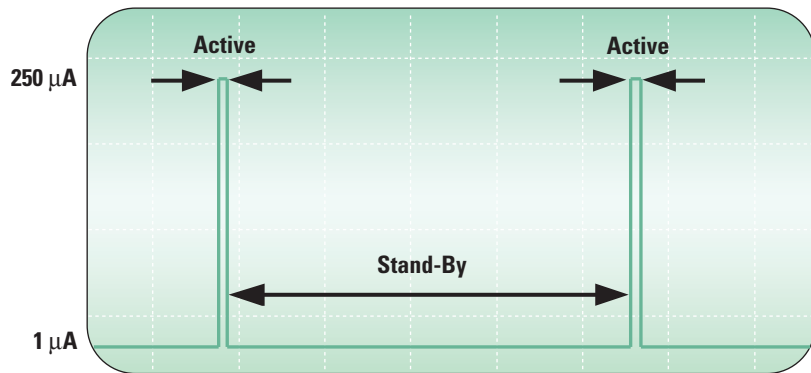
- Low-frequency auxiliary clock:
 - Ultra-low-power stand-by mode
- High-speed master clock:
 - High-performance processing
- Stability over time and temperature

The MSP430 clock system is designed specifically for battery-powered applications. Multiple oscillators are utilized to support event-driven burst activity. A low frequency Auxiliary Clock (ACLK) is driven directly from a common 32-kHz watch crystal—with no additional external components. The ACLK can be used for a background real-time clock self-wake-up function. An integrated high-speed Digitally Controlled Oscillator (DCO) can source the master clock (MCLK) used by the CPU and high-speed peripherals. By design, the DCO is active and stable in less than 6 μ s. MSP430-based solutions efficiently use 16-bit RISC CPU high-performance in very short burst intervals. This results in very high-performance and ultra-low power consumption.

Multiple Oscillator Clock System



Ultra-Low-Power Activity Profile



Ultra-fast 6- μ s DCO start-up allows MSP430 systems to remain in low-power modes for the longest possible interval—extending battery life. The DCO is fully user programmable.

ADCs

Several high-performance ADCs are available in the MSP430 family:

- 12-bit or 10-bit fast SAR ADCs
- 14-bit high-resolution SAR ADC
- 16-bit slope ADC
- 16-bit sigma delta ADC

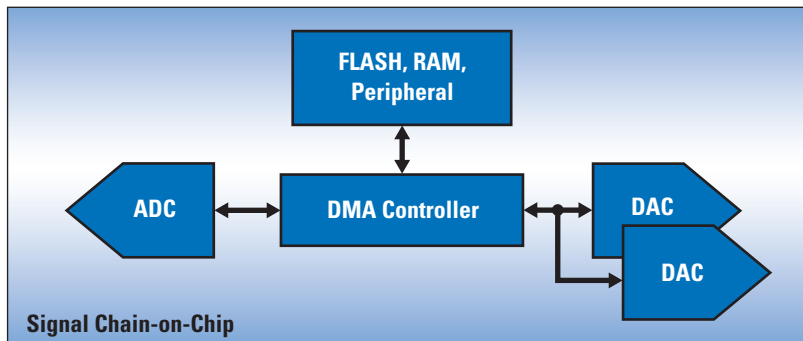
DMA

A programmable DMA controller available on all MSP430F16x/F15x parts allows for data transfer without CPU intervention which greatly increases performance.

DACs

Two integrated 12-bit DACs are provided on all MSP430F16x/F15x.

High-Performance Analog



Customers tackling the toughest low-power design challenges benefit greatly from the MSP430's Signal Chain-on-Chip (SCoC) solution. The integration of high-performance analog makes the MSP430 family ideal for power, space and cost-sensitive applications.

MSP430 New Product Selection Guide

(C) ROM (F) Flash	Program	SRAM	I/O	DMA	LCD Seg	Watchdog 16-Bit	Basic Timer (2) 8-Bit	Timer_A 16-Bit No. of C/C ¹	Timer_B 16-Bit No. of C/C ¹	USART	I ² C	SVS	Brown-Out Reset	MPY
Flash/ROM-Based F1xx Family V_{CC} 1.8-3.6 V														
MSP430F1101A	1 KB	128	14	—	—	✓	—	3	—	—	—	—	—	—
MSP430C1101	1 KB	128	14	—	—	✓	—	3	—	—	—	—	—	—
MSP430F1111A	2 KB	128	14	—	—	✓	—	3	—	—	—	—	—	—
MSP430C1111	2 KB	128	14	—	—	✓	—	3	—	—	—	—	—	—
MSP430F1121A	4 KB	256	14	—	—	✓	—	3	—	—	—	—	—	—
MSP430C1121	4 KB	256	14	—	—	✓	—	3	—	—	—	—	—	—
MSP430F1122	4 KB	256	14	—	—	✓	—	3	—	—	—	—	✓	—
MSP430C1122 ³	4 KB	256	14	—	—	✓	—	3	—	—	—	—	✓	—
MSP430F1132	8 KB	256	14	—	—	✓	—	3	—	—	—	—	✓	—
MSP430C1132 ³	8 KB	256	14	—	—	✓	—	3	—	—	—	—	✓	—
MSP430F122	4 KB	256	22	—	—	✓	—	3	—	1	—	—	—	—
MSP430F123	8 KB	256	22	—	—	✓	—	3	—	1	—	—	—	—
MSP430F1222	4 KB	256	22	—	—	✓	—	3	—	1	—	—	✓	—
MSP430F1232	8 KB	256	22	—	—	✓	—	3	—	1	—	—	✓	—
MSP430F133	8 KB	256	48	—	—	✓	—	3	3	1	—	—	—	—
MSP430C1331	8 KB	256	48	—	—	✓	—	3	3	1	—	—	—	—
MSP430F135	16 KB	512	48	—	—	✓	—	3	3	1	—	—	—	—
MSP430C1351	16 KB	512	48	—	—	✓	—	3	3	1	—	—	—	—
MSP430F147	32 KB	1024	48	—	—	✓	—	3	7	2	—	—	—	✓
MSP430F1471	32 KB	1024	48	—	—	✓	—	3	7	2	—	—	—	✓
MSP430F148	48 KB	2048	48	—	—	✓	—	3	7	2	—	—	—	✓
MSP430F1481	48 KB	2048	48	—	—	✓	—	3	7	2	—	—	—	✓
MSP430F149	60 KB	2048	48	—	—	✓	—	3	7	2	—	—	—	✓
MSP430F1491	60 KB	2048	48	—	—	✓	—	3	7	2	—	—	—	✓
MSP430F155	16 KB	512	48	✓	—	✓	—	3	3	1	✓	✓	✓	—
MSP430F156	24 KB	1024	48	✓	—	✓	—	3	3	1	✓	✓	✓	—
MSP430F157	32 KB	1024	48	✓	—	✓	—	3	3	1	✓	✓	✓	—
MSP430F167	32 KB	1024	48	✓	—	✓	—	3	7	2	✓	✓	✓	✓
MSP430F168	48 KB	2048	48	✓	—	✓	—	3	7	2	✓	✓	✓	✓
MSP430F169	60 KB	2048	48	✓	—	✓	—	3	7	2	✓	✓	✓	✓
MSP430F1610 ³	32 KB	5120	48	✓	—	✓	—	3	7	2	✓	✓	✓	✓
MSP430F1611 ³	48 KB	10240	48	✓	—	✓	—	3	7	2	✓	✓	✓	✓
MSP430F1612 ³	55 KB	5120	48	✓	—	✓	—	3	7	2	✓	✓	✓	✓
Flash/ROM-Based F4xx Family With LCD Driver V_{CC} 1.8-3.6 V														
MSP430F412	4 KB	256	48	—	96	✓	✓	3	—	—	—	✓	✓	—
MSP430C412	4 KB	256	48	—	96	✓	✓	3	—	—	—	✓	✓	—
MSP430F413	8 KB	256	48	—	96	✓	✓	3	—	—	—	✓	✓	—
MSP430C413	8 KB	256	48	—	96	✓	✓	3	—	—	—	✓	✓	—
MSP430FE412 ²	4 KB	256	14	—	128	✓	✓	3	—	—	—	✓	✓	✓
MSP430FE413 ³	8 KB	256	14	—	128	✓	✓	3	—	—	—	✓	✓	✓
MSP430F415	16 KB	512	48	—	96	✓	✓	3,5	—	—	—	✓	✓	—
MSP430F417	32 KB	1024	48	—	96	✓	✓	3,5	—	—	—	✓	✓	—
MSP430FW423	8 KB	256	48	—	96	✓	✓	3,5	—	—	—	✓	✓	—
MSP430FW425	16 KB	512	48	—	96	✓	✓	3,5	—	—	—	✓	✓	—
MSP430FW427	32 KB	1024	48	—	96	✓	✓	3,5	—	—	—	✓	✓	—
MSP430F423	8 KB	256	14	—	128	✓	✓	3	—	1	—	✓	✓	—
MSP430F425	16 KB	512	14	—	128	✓	✓	3	—	1	—	✓	✓	—
MSP430F427	32 KB	1024	14	—	128	✓	✓	3	—	1	—	✓	✓	—
MSP430FE423	8 KB	256	14	—	128	✓	✓	3	—	1	—	✓	✓	—
MSP430FE425	16 KB	512	14	—	128	✓	✓	3	—	1	—	✓	✓	—
MSP430FE427	32 KB	1024	14	—	128	✓	✓	3	—	1	—	✓	✓	—
MSP430F435	16 KB	512	48	—	128/160	✓	✓	3	3	1	—	✓	✓	—
MSP430F436	24 KB	1024	48	—	128/160	✓	✓	3	3	1	—	✓	✓	—
MSP430F437	32 KB	1024	48	—	128/160	✓	✓	3	3	1	—	✓	✓	—
MSP430FG437	32 KB	1024	48	✓	128	✓	✓	3	3	1	—	✓	✓	—
MSP430FG438	48 KB	2048	48	✓	128	✓	✓	3	3	1	—	✓	✓	—
MSP430FG439	60 KB	2048	48	✓	128	✓	✓	3	3	1	—	✓	✓	—
MSP430F447	32 KB	1024	48	—	160	✓	✓	3	7	2	—	✓	✓	✓
MSP430F448	48 KB	2048	48	—	160	✓	✓	3	7	2	—	✓	✓	✓
MSP430F449	60 KB	2048	48	—	160	✓	✓	3	7	2	—	✓	✓	✓

¹C/C = Capture/Compares

²Suggested 1,000 unit resale price in U.S. dollars.

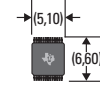
³Product Preview

All production parts support industrial temperature range.

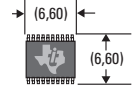
Comp_A	Temp Sensor	ADC	Additional Analog	Pins/Pkg	Price ²
✓	—	slope	—	20 DGV, DW, PW, 24 RGE	\$0.99
✓	—	slope	—	20 DW, PW, 24 RGE ³	\$0.60
✓	—	slope	—	20 DGV, DW, PW, 24 RGE	\$1.35
✓	—	slope	—	20 DW, PW, 24 RGE ³	\$1.10
✓	—	slope	—	20 DGV, DW, PW, 24 RGE	\$1.70
✓	—	slope	—	20 DW, PW, 24 RGE ³	\$1.35
—	✓	5-ch ADC10	—	20 DW,PW, 32 RHB ³	\$2.00
—	✓	5-ch ADC10	—	20 DW,PW	\$1.50
—	✓	5-ch ADC10	—	20 DW,PW, 32 RHB ³	\$2.25
—	✓	5-ch ADC10	—	20 DW,PW	\$1.70
✓	—	slope	—	28 DW,PW, 32 RHB	\$2.15
✓	—	slope	—	28 DW,PW, 32 RHB	\$2.30
—	✓	8-ch ADC10	—	28 DW,PW, 32 RHB	\$2.40
—	✓	8-ch ADC10	—	28 DW,PW, 32 RHB	\$2.50
✓	✓	8-ch ADC12	—	64 PM, RTD ³ , PAG	\$3.00
✓	—	slope	—	64 PM, RTD ³	\$2.00
✓	✓	8-ch ADC12	—	64 PM, RTD ³ , PAG	\$3.60
✓	—	slope	—	64 PM, RTD ³	\$2.30
✓	✓	8-ch ADC12	—	64 PM, RTD ³ , PAG	\$5.05
✓	—	slope	—	64 PM, RTD ³	\$4.60
✓	✓	8-ch ADC12	—	64 PM, RTD ³ , PAG	\$5.75
✓	—	slope	—	64 PM, RTD ³	\$5.30
✓	✓	8-ch ADC12	—	64 PM, RTD ³ , PAG	\$6.05
✓	—	slope	—	64 PM, RTD ³	\$5.60
✓	✓	8-ch ADC12	(2) DAC12	64 PM	\$4.95
✓	✓	8-ch ADC12	(2) DAC12	64 PM	\$5.55
✓	✓	8-ch ADC12	(2) DAC12	64 PM	\$5.85
✓	✓	8-ch ADC12	(2) DAC12	64 PM	\$6.75
✓	✓	8-ch ADC12	(2) DAC12	64 PM	\$7.45
✓	✓	8-ch ADC12	(2) DAC12	64 PM	\$7.95
✓	✓	8-ch ADC12	(2) DAC12	64 PM	\$8.25
✓	✓	8-ch ADC12	(2) DAC12	64 PM	\$8.65
✓	✓	8-ch ADC12	(2) DAC12	64 PM	\$8.95
✓	—	slope	—	64 PM, RTD ³	\$2.60
✓	—	slope	—	64 PM, RTD ³	\$1.90
✓	—	slope	—	64 PM, RTD ³	\$2.95
✓	—	slope	—	64 PM, RTD ³	\$2.10
—	✓	(2) SD16	—	64 PM	\$3.50
—	✓	(2) SD16	—	64 PM	\$3.95
✓	—	slope	—	64 PM	\$3.40
✓	—	slope	—	64 PM	\$3.90
✓	—	slope	Flow-meter	64 PM	\$3.75
✓	—	slope	Flow-meter	64 PM	\$4.05
✓	—	slope	Flow-meter	64 PM	\$4.45
—	✓	(3) SD16	—	64 PM	\$4.50
—	✓	(3) SD16	—	64 PM	\$4.95
—	✓	(3) SD16	—	64 PM	\$5.40
—	✓	(3) SD16	E meter	64 PM	\$4.85
—	✓	(3) SD16	E meter	64 PM	\$5.45
—	✓	(3) SD16	E meter	64 PM	\$5.95
✓	✓	8-ch ADC12	—	80 PN, 100 PZ	\$4.45
✓	✓	8-ch ADC12	—	80 PN, 100 PZ	\$4.70
✓	✓	8-ch ADC12	—	80 PN, 100 PZ	\$4.90
✓	✓	12-ch ADC12	(2) DAC12, (3) OPAMP	80 PN	\$6.50
✓	✓	12-ch ADC12	(2) DAC12, (3) OPAMP	80 PN	\$7.35
✓	✓	12-ch ADC12	(2) DAC12, (3) OPAMP	80 PN	\$7.95
✓	✓	8-ch ADC12	—	100 PZ	\$5.75
✓	✓	8-ch ADC12	—	100 PZ	\$6.50
✓	✓	8-ch ADC12	—	100 PZ	\$7.05

Selected Package Options for MSP430 Devices

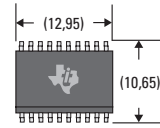
20-pin DGV (TVSOP)



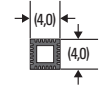
20-pin PW (TSSOP)



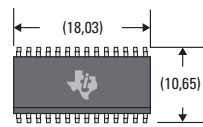
20-pin DW (SOP)



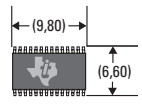
24-pin RGE (QFN)



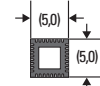
28-pin DW (SOP)



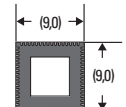
28-pin PW (TSSOP)



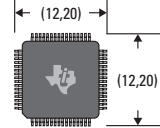
32-pin RHB (QFN)



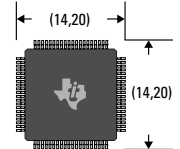
64-pin RTD (QFN)



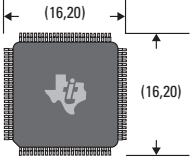
64-pin PM, PAG (LQFP/TQFP)



80-pin PN (LQFP)



100-pin PZ (LQFP)



All dimensions in millimeters.

How To Get Started:

Product Selection: If you are not sure which MSP430 device best fits the performance, cost and power needs of your application, please refer to the selection guide on the previous page or visit the MSP430 home page at: www.ti.com/msp430

Development Tool Selection:

TI IDE	Product Family	Price ¹
MSP-FET430P120	MSP430x11x1A, MSP430x12x/x1xx2	\$ 99
MSP-FET430P140	MSP430x13x/x14x/x15x/x16x	\$ 99
MSP-FET430P410	MSP430x41x, MSP430FE42x, MSP430FW42x	\$ 99
MSP-FET430P430 ²	MSP430FG43x, MSP430x43x	\$ 99
MSP-FET430P440	MSP430x43x/x44x	\$ 99
MSP-GANG430	MSP430F1xx, MSP430F4xx	\$ 199

¹Price per unit in U.S. dollars. ²Available in 80-pin package version only.

Volume Production Programming:

MSP-GANG430 Programmer

The MSP-GANG430 is a universal Flash device programmer, which can program up to eight targets simultaneously with speeds up to 60 KB in 12 seconds. The MSP-GANG430 can operate stand-alone or connected to the host PC via a standard RS232 serial connection. Devices are programmed as either stand-alone or in-system using a JTAG connection. The MSP-GANG430 Programmer is available from a TI authorized distributor for \$199.

In-System Production Programming

JTAG: Programming through JTAG is supported with all MSP430 Flash, OTP or UV devices. A security fuse can be blown to sever JTAG access and prevent reverse engineering. Customers can use the MSP-GANG430 or build their own interface.

Bootstrap Loader: On all MSP430 Flash devices, the bootstrap loader (BSL), is part of factory-masked ROM and can be implemented via a software UART. Single devices are programmed either stand-alone or in-system. Program, verify, read out and segment erase are password protected.

For further information on JTAG and Bootstrap Loader, go to www.ti.com/msp430appnotes and download Application Notes SLAA149, SLAA089a and SLAA096b.

ROM

For high-volume OEM customers, masked ROM devices can be ordered (applicable to ROM devices listed on pages 4-5). The ROM process takes approximately 10-12 weeks from the receipt of a customer's code to the production of the first silicon. A customer-specific coded part number will be released.

Third Party Production Programmers

MSP430 devices may also be programmed by manual and automated production programming systems from third party vendors such as SoftBaugh, BP Microsystems, Data I/O and others.

www.softbaugh.com
www.bpmicro.com
www.dataio.com

Third Party Integrated Development Environments:



Baseline and full C-Compiler versions are available from IAR as enhancements to the 4-KB C-compiler included with TI's MSP430 tools.

www.iar.com



The new third party unlimited C-compiler for only \$395 enables customers to develop and debug software.

www.quadravox.com/AQ430.htm



Learn more about *CrossWorks*, Rowley's complete MSP430 development solution, which includes an optimized C-compiler and assembler at:

www.rowley.co.uk



Standard C development tool available at \$199. Bundled standard tool with NoICE430 debugger available for \$299. Download a free 30-day demo at:

www.imagecraft.com

MSP-FET430 Flash Emulation Tool

- JTAG based real-time in-system emulation
- Target board, interface box, cable and samples
- CD-ROM includes Kickstart IDE, assembler, linker, simulator and 4-KB C-compiler

The Flash Emulation Tool (FET) supports complete in-system development and is available for all MSP430F1xx and MSP430F4xx Flash devices. Programming, assembler/C-source level debug, single stepping, multiple hardware breakpoints, full-speed operation and peripheral access are all fully supported in-system using JTAG. The FET comes complete with everything required to complete an entire project.

Embedded Emulation With the MSP430

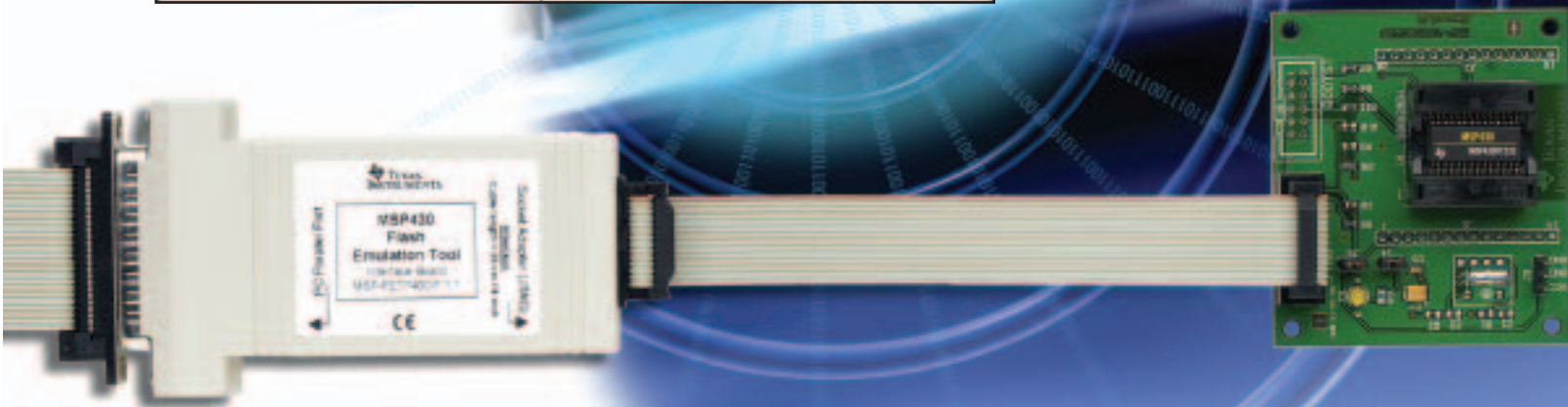
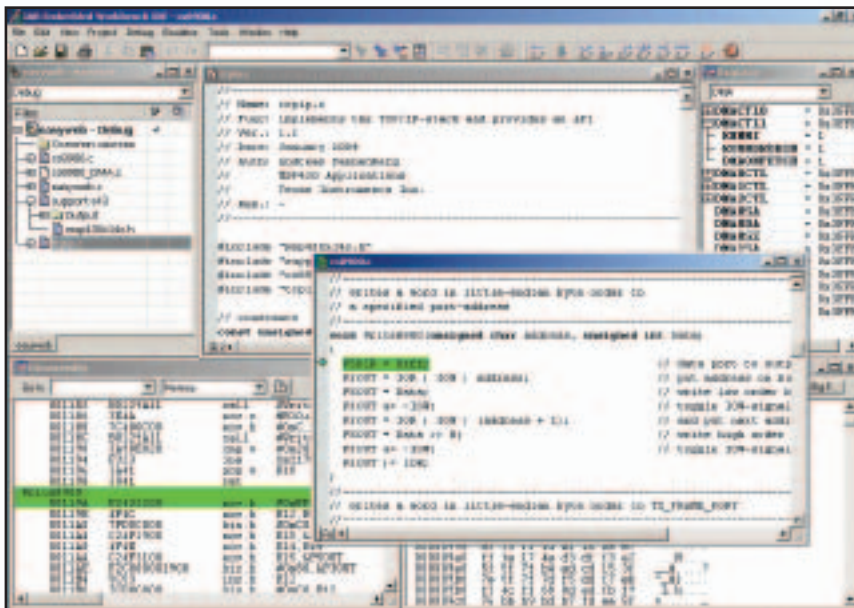
- Development is in-system and subject to the exact same characteristics of the final application
- Non-obtrusive in portable and high-pin count situations
- Common user software and physical interface

Today's applications operating at lower voltages, with tighter packaging and higher-precision analog, benefit greatly from the MSP430's in-system emulation approach. The MSP430's dedicated embedded emulation logic resides on the actual device itself and is accessed via industry standard JTAG using no additional system resources. From the first day of development, firmware engineers can now unobtrusively develop and debug their

embedded code with full-speed execution, breakpoints, and single steps in an application.

Embedded emulation becomes even more important with high-performance mixed-signal systems that must maintain the integrity of microvolt analog signals. Signal integrity is virtually impossible with cumbersome in-circuit emulators that are sensitive to cabling crosstalk. And, unlike abstract background debuggers, no time-sharing of system serial communication resources is required with embedded emulation on the MSP430.

By combining the flexibility of in-system programmable Flash memory, unobtrusive embedded emulation, and a common user interface, development time is reduced. And, should the situation arise, last minute code updates as well as remote scheduled and unscheduled upgrades can also be made.



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