MSP430 Ultra-Low-Power MCUs

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)
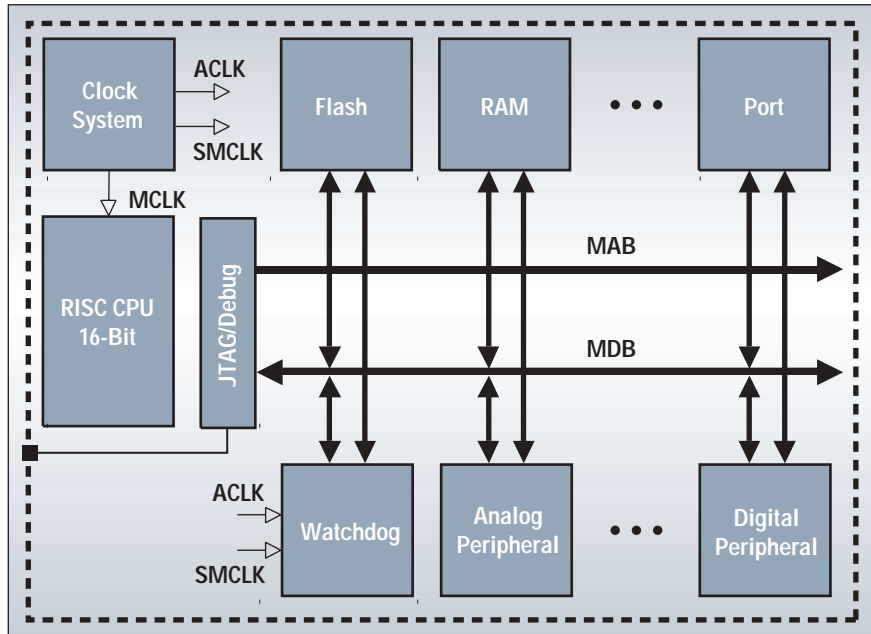- RAM up to 10 kB

Analog Peripherals

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

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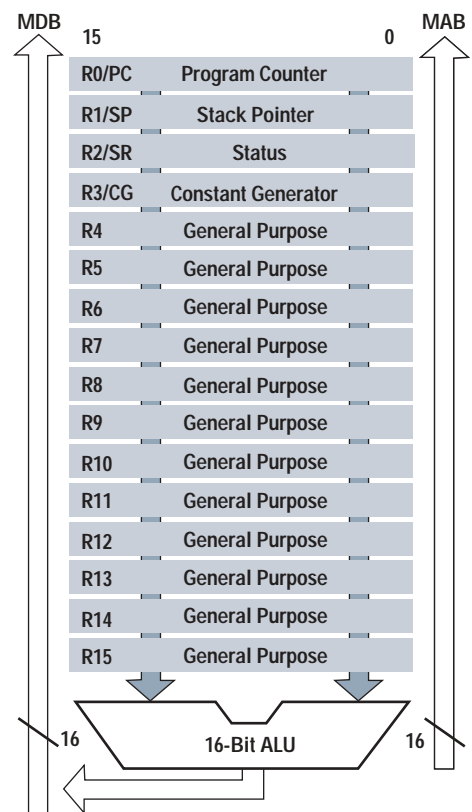
The MSP430 CPU core with sixteen 16-bit registers, 27 single-cycle instructions and seven addressing modes results in higher processing efficiency and code density.

2

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 µs. 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.

High-Performance Analog

- 12-bit or 10-bit fast SAR ADC
- 14-bit hi-res SAR ADC
- 16-bit slope ADC
- 12-bit DAC

Several high-performance data converter solutions are available in the MSP430 family. Innovative comparator-gated timers are available on all devices for high-resolution slope type conversions. This is ideal for measuring resistive sensors such as thermistors when coupled with a capacitor. A fast 200-ksps+ 12-bit ADC with very high-integration is available on the MSP430F13x/14x/16x/43x/44x and is ideal for demanding applications such as electricity meters and digital motor control. MSP430x32x derivatives offer a 14-bit ADC with a programmable current source.

Multiple Oscillator Clock System
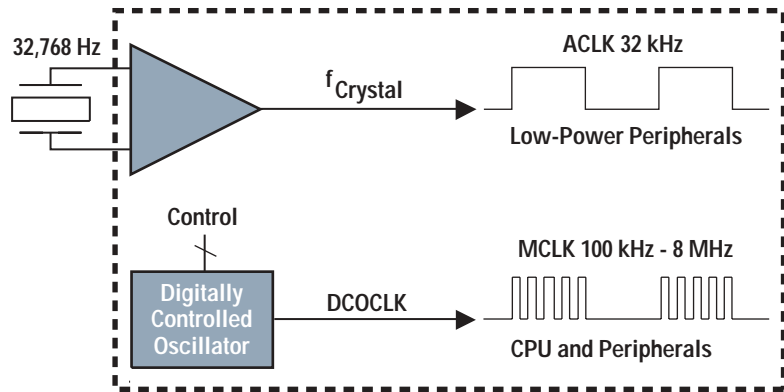
Ultra-Low-Power Activity Profile
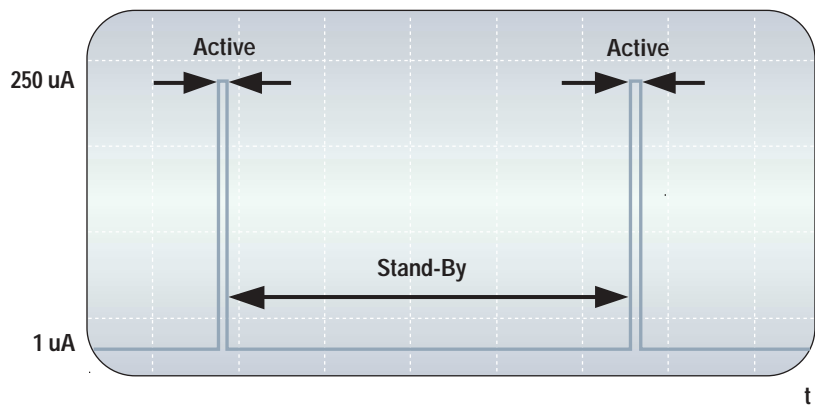
Ultra-fast 6µs DCO start-up allows MSP430 systems to remain in low-power modes for the longest possible interval—extending battery life. The DCO is fully user programmable.

ADC12

ADC12 with 200 ksps+, auto-scan, V_{REF}, temperature sensor, and programmable sample and hold intervals.

MSP430 Product Selection Guide

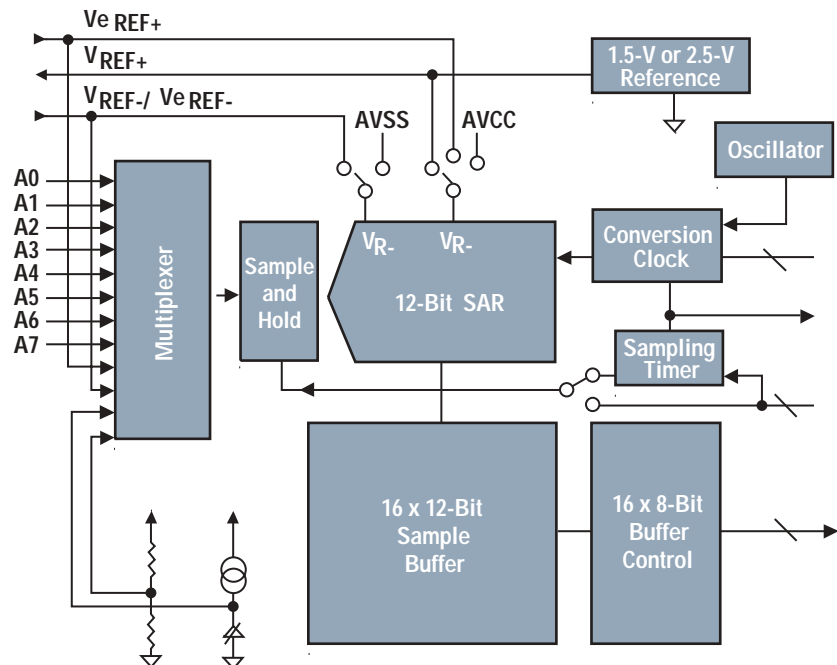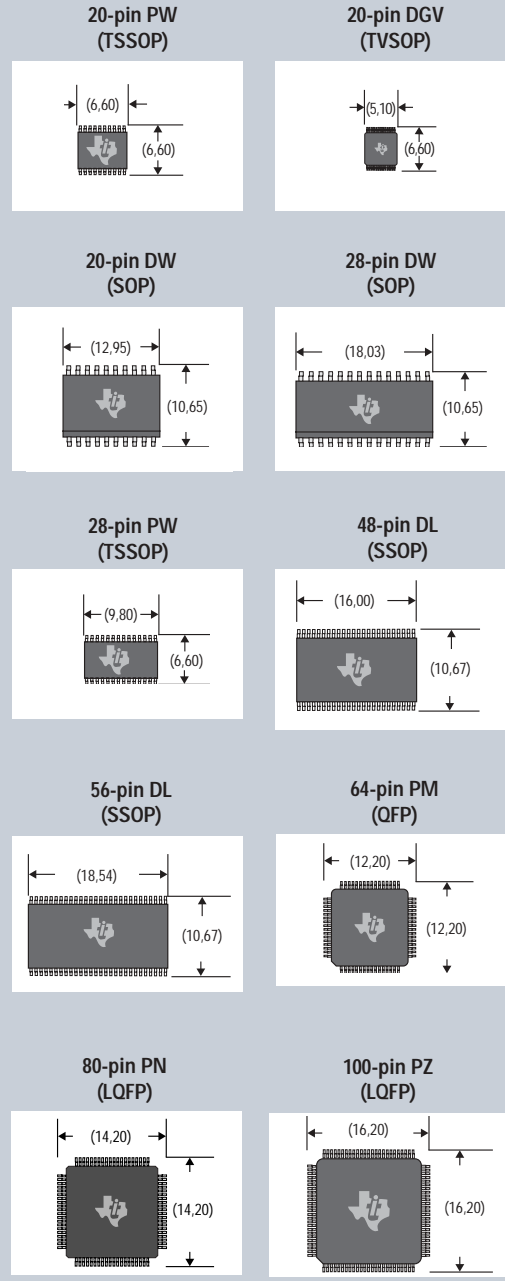| (C)ROM (E)UV (F) Flash (P)OTP	Program	SRAM	I/O	LCD Seg	Watchdog 16-Bit	Basic Timer (2) 8-Bit	Interval Timer 8-Bit	Timer/ Port (2) 8-Bit	Timer_A 16-Blt	Timer_B 16-Bit	USART	I2C
Flash Based F1xx Family V$_{CC}$ 1.8-3.6 V												
MSP430F1101A	1 kB	128	14	–	✔	–	–	–	✔	–	–	–
MSP430C1101	1 kB	128	14	–	✔	–	–	–	✔	–	–	–
MSP430F1111A	2 kB	128	14	–	✔	–	–	–	✔	–	–	–
MSP430C1111	2 kB	128	14	–	✔	–	–	–	✔	–	–	–
MSP430F1121A	4 kB	256	14	–	✔	–	–	–	✔	–	–	–
MSP430C1121	4 kB	256	14	–	✔	–	–	–	✔	–	–	–
MSP430P112[2]	4 kB	256	14	–	✔	–	–	–	✔	–	–	–
MSP430F1122	4 kB	256	14	–	✔	–	–	–	✔	–	–	–
MSP430F1132	8 kB	256	14	–	✔	–	–	–	✔	–	–	–
MSP430F122	4 kB	256	22	–	✔	–	–	–	✔	–	1	–
MSP430F123	8 kB	256	22	–	✔	–	–	–	✔	–	1	–
MSP430F1222	4 kB	256	22	–	✔	–	–	–	✔	–	1	–
MSP430F1232	8 kB	256	22	–	✔	–	–	–	✔	–	1	–
MSP430F133	8 kB	256	48	–	✔	–	–	–	✔	✔	1	–
MSP430F135	16 kB	512	48	–	✔	–	–	–	✔	✔	1	–
MSP430C1331	8 kB	256	48	–	✔	–	–	–	✔	✔	1	–
MSP430C1351	16 kB	512	48	–	✔	–	–	–	✔	✔	1	–
MSP430F147	32 kB	1024	48	–	✔	–	–	–	✔	✔	2	–
MSP430F148	48 kB	2048	48	–	✔	–	–	–	✔	✔	2	–
MSP430F149	60 kB	2048	48	–	✔	–	–	–	✔	✔	2	–
MSP430F155[3]	16 kB	512	48	–	✔	–	–	–	✔	✔	1	✔
MSP430F156[3]	24 kB	1024	48	–	✔	–	–	–	✔	✔	1	✔
MSP430F157[3]	32 kB	1024	48	–	✔	–	–	–	✔	✔	1	✔
MSP430F167[3]	32kB	1024	48	–	✔	–	–	–	✔	✔	2	✔
MSP430F168[3]	48 kB	2048	48	–	✔	–	–	–	✔	✔	2	✔
MSP430F169[3]	60 kB	2048	48	–	✔	–	–	–	✔	✔	2	✔
MSP430F1610[4]	32 kB	5120	48	–	✔	–	–	–	✔	✔	2	✔
MSP430F1611[4]	48 kB	10240	48	–	✔	–	–	–	✔	✔	2	✔
Flash Based F4xx Family with LCD Driver V$_{CC}$ 1.8-3.6 V												
MSP430F412	4 kB	256	48	96	✔	✔	–	–	✔	–	–	–
MSP430C412	4 kB	256	48	96	✔	✔	–	–	✔	–	–	–
MSP430F413	8 kB	256	48	96	✔	✔	–	–	✔	–	–	–
MSP430C413	8 kB	256	48	96	✔	✔	–	–	✔	–	–	–
MSP430F435	16 kB	512	48	128/160	✔	✔	–	–	✔	✔	1	–
MSP430F436	24 kB	1024	48	128/160	✔	✔	–	–	✔	✔	1	–
MSP430F437	32 kB	1024	48	128/160	✔	✔	–	–	✔	✔	1	–
MSP430F447	32 kB	1024	48	160	✔	✔	–	–	✔	✔	2	–
MSP430F448	48 kB	2048	48	160	✔	✔	–	–	✔	✔	2	–
MSP430F449	60 kB	2048	48	160	✔	✔	–	–	✔	✔	2	–
ROM/OTP Based X3xx Family with LCD Driver ROM V$_{CC}$ 2.5-5.5 V/OTP V$_{CC}$ 2.7-5.5V												
MSP430C311S	2 kB	128	11	64	✔	✔	✔	✔	–	–	–	–
MSP430P315S	16 kB	512	11	64	✔	✔	✔	✔	–	–	–	–
MSP430C312	4 kB	256	14	92	✔	✔	✔	✔	–	–	–	–
MSP430C313	8 kB	256	14	92	✔	✔	✔	✔	–	–	–	–
MSP430C314	12 kB	512	14	92	✔	✔	✔	✔	–	–	–	–
MSP430C315	16 kB	512	14	92	✔	✔	✔	✔	–	–	–	–
MSP430P315	16 kB	512	14	92	✔	✔	✔	✔	–	–	–	–
MSP430C323	8 kB	256	14	84	✔	✔	✔	✔	–	–	–	–
MSP430C325	16 kB	512	14	84	✔	✔	✔	✔	–	–	–	–
MSP430P325A	16 kB	512	14	84	✔	✔	✔	✔	–	–	–	–
MSP430C336	24 kB	1024	40	120	✔	✔	✔	✔	✔	–	1	–
MSP430C337	32 kB	1024	40	120	✔	✔	✔	✔	✔	–	1	–
MSP430P337A	32 kB	1024	40	120	✔	✔	✔	✔	✔	–	1	–

[1]Suggested 10,000 unit resale price in U.S. dollars. [2]V$_{CC}$ 2.5-5.5V [3]Planned release Q2 2003. [4]Planned release Q4 2003.
All production parts support industrial temperature range.

SVS	BOR	MPY	Comp_A	ADC	DAC	Pins/Pkg	Price[1]
–	–	–	✔	slope	–	20 DW,PW	$0.99
–	–	–	✔	slope	–	20 DW,PW	$0.60
–	–	–	✔	slope	–	20 DW,PW	$1.34
–	–	–	✔	slope	–	20 DW,PW	$1.10
–	–	–	✔	slope	–	20 DW,PW, DGV	$1.74
–	–	–	✔	slope	–	20 DW,PW	$1.34
–	–	–	–	slope	–	20 DW,PW	$2.33
–	✔	–	–	5ch ADC10	–	20 DW,PW	$2.24
–	✔	–	–	5ch ADC10	–	20 DW,PW	$2.48
–	–	–	✔	slope	–	28 DW,PW	$2.39
–	–	–	✔	slope	–	28 DW,PW	$2.51
–	✔	–	–	8ch ADC10	–	28 DW,PW	$2.62
–	✔	–	–	8ch ADC10	–	28 DW,PW	$2.79
–	–	–	✔	8ch ADC12	–	64 PM	$2.96
–	–	–	✔	8ch ADC12	–	64 PM	$3.55
–	–	–	✔	slope	–	64 PM	$1.95
–	–	–	✔	slope	–	64 PM	$2.25
–	–	✔	✔	8ch ADC12	–	64 PM	$4.95
–	–	✔	✔	8ch ADC12	–	64 PM	$5.65
–	–	✔	✔	8ch ADC12	–	64 PM, PAG	$5.95
✔	✔	–	✔	8ch ADC12	2ch DAC12	64 PM	$4.95
✔	✔	–	✔	8ch ADC12	2ch DAC12	64 PM	$5.65
✔	✔	–	✔	8ch ADC12	2ch DAC12	64 PM	$5.85
✔	✔	✔	✔	8ch ADC12	2ch DAC12	64 PM	$6.73
✔	✔	✔	✔	8ch ADC12	2ch DAC12	64 PM	$7.45
✔	✔	✔	✔	8ch ADC12	2ch DAC12	64 PM	$7.95
✔	✔	✔	✔	8ch ADC12	2ch DAC12	64 PM	$8.45
✔	✔	✔	✔	8ch ADC12	2ch DAC12	64 PM	$8.95
✔	✔	–	✔	slope	–	64 PM	$2.55
✔	✔	–	✔	slope	–	64 PM	$1.90
✔	✔	–	✔	slope	–	64 PM	$2.90
✔	✔	–	✔	slope	–	64 PM	$2.10
✔	✔	–	✔	8ch ADC12	–	80 PN, 100 PZ	$4.40
✔	✔	–	✔	8ch ADC12	–	80 PN, 100 PZ	$4.65
✔	✔	–	✔	8ch ADC12	–	80 PN, 100 PZ	$4.85
✔	✔	✔	✔	8ch ADC12	–	100 PZ	$5.65
✔	✔	✔	✔	8ch ADC12	–	100 PZ	$6.40
✔	✔	✔	✔	8ch ADC12	–	100 PZ	$6.95
–	–	–	–	slope	–	48DL	$1.99
–	–	–	–	slope	–	48DL	$5.16
–	–	–	–	slope	–	56 DL	$2.40
–	–	–	–	slope	–	56 DL	$2.61
–	–	–	–	slope	–	56 DL	$2.82
–	–	–	–	slope	–	56 DL	$3.04
–	–	–	–	slope	–	56 DL	$5.16
–	–	–	–	6ch ADC14	–	64 PM, FN, PG	$5.23
–	–	–	–	6ch ADC14	–	64 PM, FN, PG	$5.53
–	–	–	–	6ch ADC14	–	64 PM, FN, PG	$6.87
–	–	✔	–	slope	–	100 PJM	$6.10
–	–	✔	–	slope	–	100 PJM	$6.38
–	–	✔	–	slope	–	100 PJM	$7.53

Selected Package Options for MSP430 Devices

20-pin PW (TSSOP)
(6,60)
(6,60)

20-pin DGV (TVSOP)
(5,10)
(6,60)

20-pin DW (SOP)
(12,95)
(10,65)

28-pin DW (SOP)
(18,03)
(10,65)

28-pin PW (TSSOP)
(9,80)
(6,60)

48-pin DL (SSOP)
(16,00)
(10,67)

56-pin DL (SSOP)
(18,54)
(10,67)

64-pin PM (QFP)
(12,20)
(12,20)

80-pin PN (LQFP)
(14,20)
(14,20)

100-pin PZ (LQFP)
(16,20)
(16,20)

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-FET430X110	MSP430x11xA	$ 49
MSP-FET430P120	MSP430x12x/x1xx2	$ 99
MSP-FET430P140	MSP430x13x/14x/x15x/x16x	$ 99
MSP-FET430P410	MSP430x41x	$ 99
MSP-FET430P440	MSP430x43x/44x	$ 99
MSP-EVK430S320	MSP430x31x/32x	$ 399
MSP-EVK430S330	MSP430x33x	$ 399
MSP-PRGS430	All	$ 199

[1]Price per unit in U.S. dollars.

Volume Production Programming:

MSP-PRGS430 Universal Programmer

The MSP-PRGS430 is a universal Flash, OTP or UV device programmer. Control of the programmer is provided through a PC serial port connection and a user interface. Single devices are programmed either stand-alone or in-system using a JTAG connection. The MSP-PRGS430 is available for $199 from a TI authorized distributor.

Third Party Production Programmers

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

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-PRGS430 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.

Additional Resources:

Visit our Web site for documentation, downloadable code, software updates and complete information on TI and third party support.

www.ti.com/msp430

IAR MSP430 C-Compiler

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

6

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.
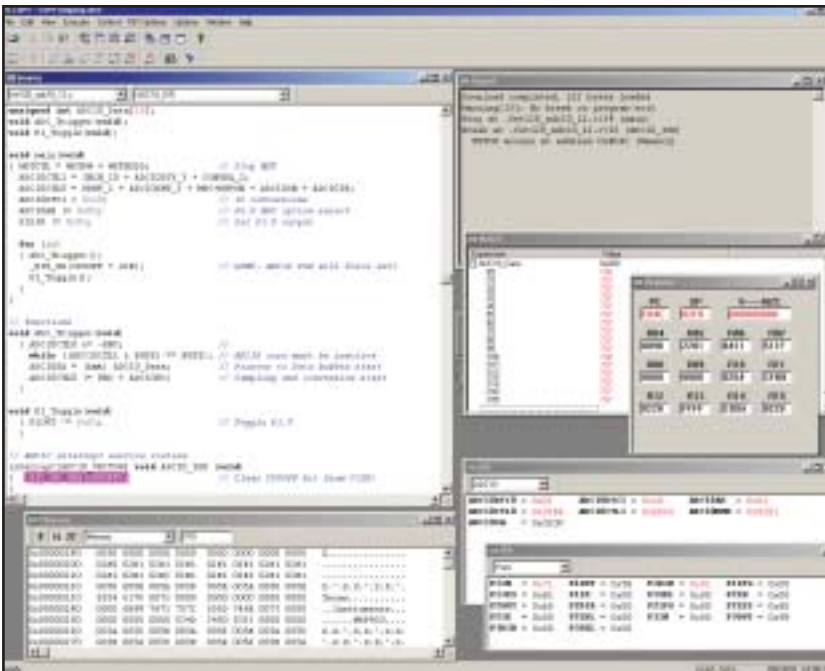
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support.ti.com/sc/knowledgebase

Product Information Centers

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Italy	800 79 11 37
Netherlands (English)	+31 (0) 546 87 95 45
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Sweden (English)	+46 (0) 8587 555 22
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Internet	support.ti.com/sc/pic/euro.htm

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	Domestic	0120-81-0036
Internet/Email	International	support.ti.com/sc/pic/japan.htm
	Domestic	www.tij.co.jp/pic

Asia

Phone

International	+886-2-23786800
Domestic	Toll-Free Number
Australia	1-800-999-084
China	108-00-886-0015
Hong Kong	800-96-5941
Indonesia	001-803-8861-1006
Korea	080-551-2804
Malaysia	1-800-80-3973
New Zealand	0800-446-934
Philippines	1-800-765-7404
Singapore	800-886-1028
Taiwan	0800-006800
Thailand	001-800-886-0010
Fax	886-2-2378-6808
Email	tiasia@ti.com
Internet	support.ti.com/sc/pic/asia.htm

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TEXAS INSTRUMENTS

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