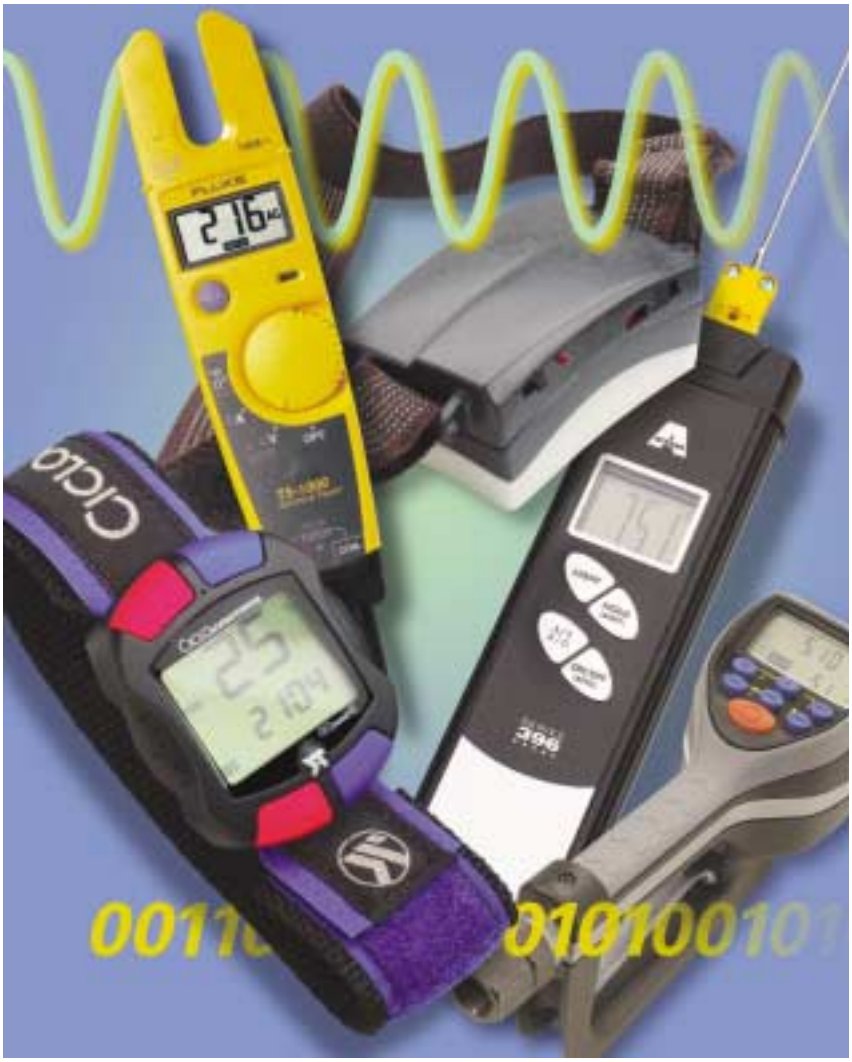
*Product Bulletin Q4-2001*

# MSP430 Ultra-Low-Power Microcontrollers—The Solution for Battery-Powered Measurement

The MSP430 family of ultra-low-power 16-bit RISC mixed-signal processors from Texas Instruments (TI) provides the ultimate solution for battery-powered measurement applications. For low-power applications where both analog and digital signal processing are required, the MSP430 line provides a range of exceptional cost/performance options. Using its leadership in both mixed-signal and digital technologies, TI has created the MSP430 family which enables system designers to simultaneously interface to analog signals, sensors and digital components while maintaining unmatched low power.



***Key Features***

- Ultra-low-power architecture extends battery life
  - 0.1µA RAM retention
  - 0.8µA real-time clock mode
  - 250µA / 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 starting at $0.99

## *Applications*

When battery life, processing power and hardware flexibility are major design concerns, TI's MSP430 family offers an unbeatable combination of features.

The MSP430 family is suitable for applications such as:

- *Utility metering—gas, water, electric, heat allocators, thermostats*
- *Portable instrumentation—glucose meters, heart-rate monitors, thermometers, multi-meters, weight scales*
- *Intelligent sensing—security systems, smoke detectors, electronic tags*

The MSP430 line of ultra-low-power microcontrollers offers solutions that enable product ideas to become reality.

## MSP430 Architecture

Using a von-Neumann common memory address bus (MAB) and memory data bus (MDB), a 16-bit RISC CPU, peripherals and flexible clock system are combined. 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 2 kB

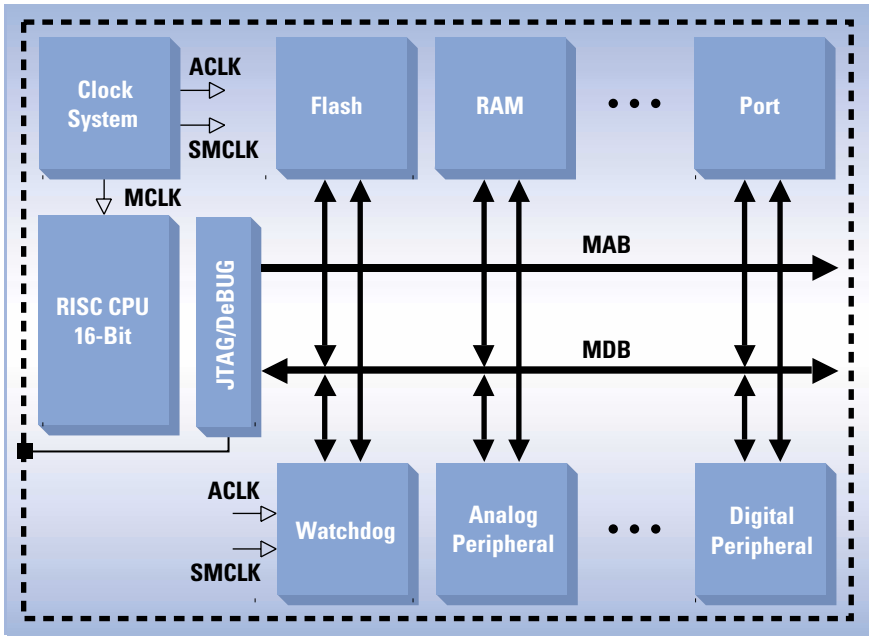
## Analog Peripherals

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

## Digital Peripherals

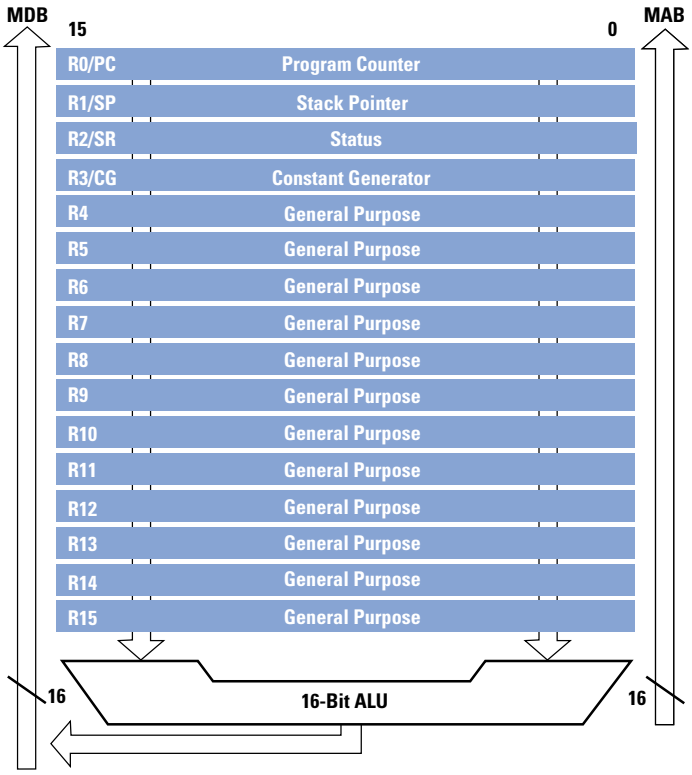
- USART
- Hardware multiplier
- 16-bit and 8-bit timers

### In-Circuit Programmable MSP430 Flash




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

### 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.*

## 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 CPU that is more processing effective, consumes little power, is smaller and more code efficient. New ultra-low-power high-performance applications are now possible—developed rapidly at a fraction of the code size.

## 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

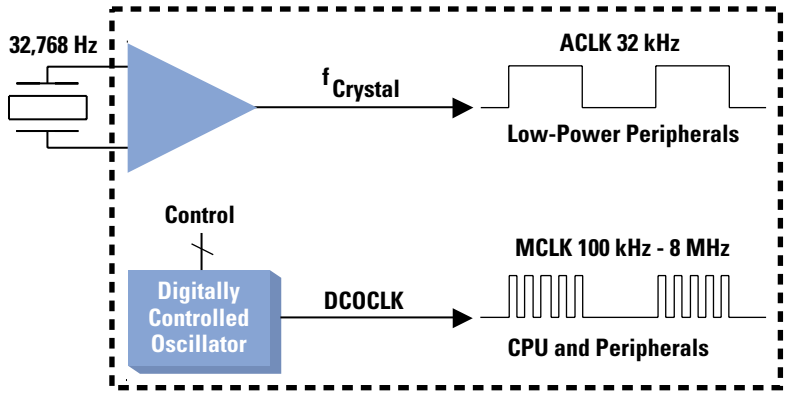
The MSP430 clock system is designed specifically for battery-powered applications. Multiple oscillators are utilized to support event driven burst activity. A low frequency Auxiliary Clock (ACLK) is driven directly from a common 32-kHz watch crystal—with no additional external components. The ACLK can 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 which is 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 high-performance in very short burst intervals. This results in very high-performance and ultra-low power consumption.

## High-Performance Analog

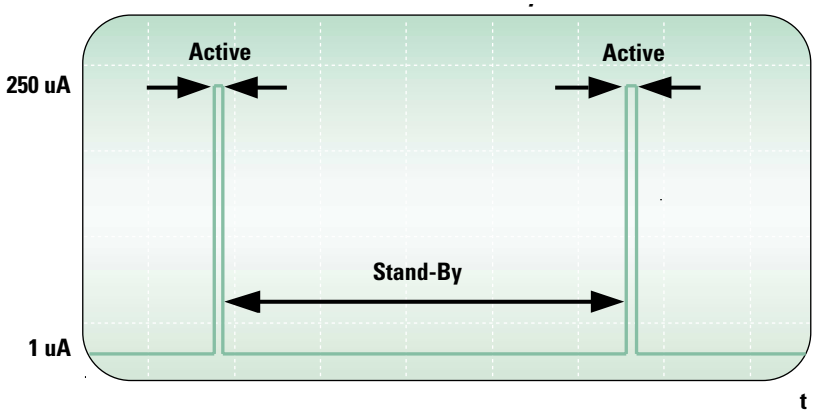
- 12-bit or 10-bit fast SAR ADC
- 14-bit hi-res SAR ADC
- 16-bit slope ADC

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/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

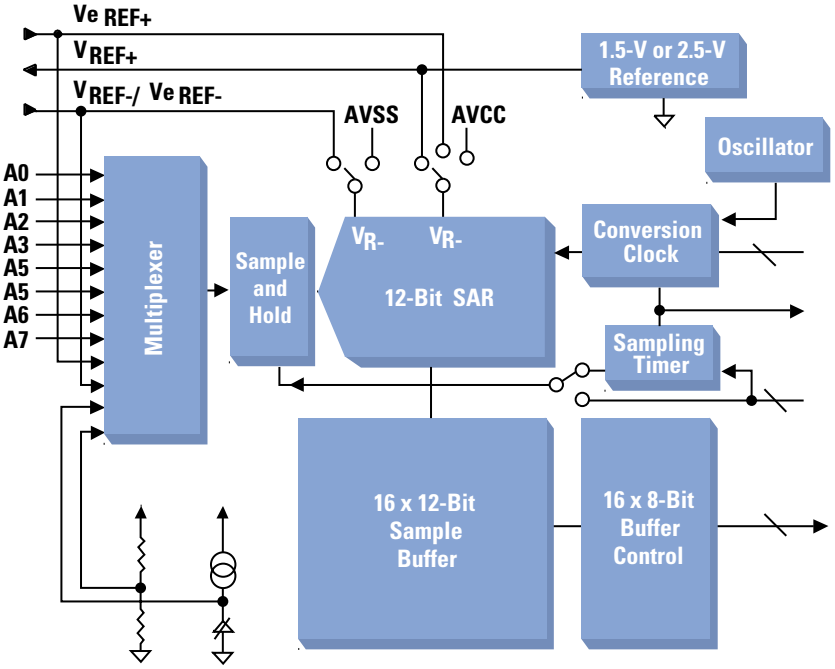



### Ultra-Low-Power Activity Profile




*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.*

### *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 2-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.

### *MSP-EVKS330/320 Evaluation Kit*

For MSP430x3xx devices, evaluation kits (EVK) are available for basic development and evaluation. EVKs include two UV erasable prototyping devices, a target board and a programmer—all software and documentation is included on a CD-ROM. For professional MSP430x3xx development, in-circuit emulators are available from Hitex.

### *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. Devices are programmed either stand-alone or in-system using a JTAG connection.

Visit our web site for documentation, downloadable code, software updates and complete information on TI and third party support.
**www.ti.com/sc/msp430**




| TI IDE | Product Family | Price[1] |
|---|---|---|
| MSP-FET430X110 | MSP430x11x | $ 49 |
| MSP-FET430P120 | MSP430x12x | $ 99 |
| MSP-FET430P140 | MSP430x13x/14x | $ 99 |
| MSP-FET430P410 | MSP430x41x | $ 99 |
| MSP-FET430P440[2] | MSP430x43x/44x | $ 99 |
| MSP-EVK430S320 | MSP430x31x/32x | $399 |
| MSP-EVK430S330 | MSP430x33x | $399 |
| MSP-PRGS430 | All | $199 |

[1]Price per unit in U.S. dollars. [2]Planned release Q1 2002.

IAR SYSTEMS

### *IAR MSP430 C-Compiler*

Baseline and full C-Compiler versions are available from IAR as enhancements to the 2-kB C-compiler included with TI's MSP430 tools.
**www.iar.com**

hitex DEVELOPMENT TOOLS

### *Hitex MSP430 ICE*

With the Dprobe430, Hitex offers a modular emulation system, specifically designed to develop, test and optimize MSP430x3xx/ MSP430x1xx applications.
**www.hitex.com**

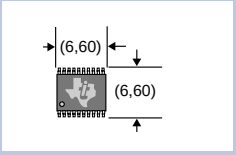
## MSP430 Product Selection Guide

| (C)ROM (E)UV (F) Flash (P)OTP | Temp Range[1] | Pins/ Pkg | Program | SRAM | I/O | Vcc | LCD Seg | Basic Timer (2) 8-Bit | Watchdog 16-Bit | Interval Timer 8-Bit | Timer/ Port (2) 8-Bit | Timer_A 16-Blt | Timer_B 16-Bit | USART | MPY | Comp_A | ADC | Price[2] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Flash Based F1xx Family** | | | | | | | | | | | | | | | | | | |
| MSP430F1101 | I | 20 DW,PW | 1 kB | 128 | 14 | 1.8 - 3.6 | – | – | X | – | – | X | – | – | – | X | slope | $0.99 |
| MSP430F1111 | I | 20 DW,PW | 2 kB | 128 | 14 | 1.8 - 3.6 | – | – | X | – | – | X | – | – | – | X | slope | $1.34 |
| MSP430C1111 | I | 20 DW,PW | 2 kB | 128 | 14 | 1.8 - 3.6 | – | – | X | – | – | X | – | – | – | X | slope | $1.23 |
| MSP430F1121 | I | 20 DW,PW, DGV | 4 kB | 256 | 14 | 1.8 - 3.6 | – | – | X | – | – | X | – | – | – | X | slope | $1.74 |
| MSP430C1121 | I | 20 DW,PW, DGV | 4 kB | 256 | 14 | 1.8 - 3.6 | – | – | X | – | – | X | – | – | – | X | slope | $1.47 |
| MSP430P112 | I | 20 DW,PW | 4 kB | 256 | 14 | 2.7 - 5.5 | – | – | X | – | – | X | – | – | – | – | slope | $2.33 |
| PMS430E112 | 25C | 20 CDIP | 4 kB | 256 | 14 | 2.7 - 5.5 | – | – | X | – | – | X | – | – | – | – | slope | $49.00 |
| MSP430F1122[4] | I | 20 DW,PW | 4 kB | 256 | 14 | 1.8 - 3.6 | – | – | X | – | – | X | – | – | – | – | ADC10 | $2.24 |
| MSP430F1132[4] | I | 20 DW,PW | 8 kB | 256 | 14 | 1.8 - 3.6 | – | – | X | – | – | X | – | – | – | – | ADC10 | $2.48 |
| MSP430F122 | I | 28 DW,PW | 4 kB | 256 | 22 | 1.8 - 3.6 | – | – | X | – | – | X | – | 1 | – | X | slope | $2.39 |
| MSP430F123 | I | 28 DW,PW | 8 kB | 256 | 22 | 1.8 - 3.6 | – | – | X | – | – | X | – | 1 | – | X | slope | $2.51 |
| MSP430F1222[4] | I | 28 DW,PW | 4 kB | 256 | 22 | 1.8 - 3.6 | – | – | X | – | – | X | – | 1 | – | – | ADC10 | $2.62 |
| MSP430F1232[4] | I | 28 DW,PW | 8 kB | 256 | 22 | 1.8 - 3.6 | – | – | X | – | – | X | – | 1 | – | – | ADC10 | $2.79 |
| MSP430F133 | I | 64 PM | 8 kB | 256 | 48 | 1.8 - 3.6 | – | – | X | – | – | X | X | 1 | – | X | ADC12 | $2.96 |
| MSP430F135 | I | 64 PM | 16 kB | 512 | 48 | 1.8 - 3.6 | – | – | X | – | – | X | X | 1 | – | X | ADC12 | $3.55 |
| MSP430C1331 | I | 64 PM | 8 kB | 256 | 48 | 1.8 - 3.6 | – | – | X | – | – | X | X | 1 | – | X | slope | $1.95 |
| MSP430C1351 | I | 64 PM | 16 kB | 512 | 48 | 1.8 - 3.6 | – | – | X | – | – | X | X | 1 | – | X | slope | $2.25 |
| MSP430F147 | I | 64 PM | 32 kB | 1024 | 48 | 1.8 - 3.6 | – | – | X | – | – | X | X | 2 | X | X | ADC12 | $4.95 |
| MSP430F148 | I | 64 PM | 48 kB | 2048 | 48 | 1.8 - 3.6 | – | – | X | – | – | X | X | 2 | X | X | ADC12 | $5.65 |
| MSP430F149 | I | 64 PM, PAG | 60 kB | 2048 | 48 | 1.8 - 3.6 | – | – | X | – | – | X | X | 2 | X | X | ADC12 | $5.95 |
| **Flash Based F4xx Family with LCD Driver** | | | | | | | | | | | | | | | | | | |
| MSP430F412 | I | 64 PM | 4 kB | 256 | 48 | 1.8 - 3.6 | 96 | X | X | – | – | X | – | – | – | X | slope | $2.55 |
| MSP430C412[4] | I | 64 PM | 4 kB | 256 | 48 | 1.8 - 3.6 | 96 | X | X | – | – | X | – | – | – | X | slope | $1.90 |
| MSP430F413 | I | 64 PM | 8 kB | 256 | 48 | 1.8 - 3.6 | 96 | X | X | – | – | X | – | – | – | X | slope | $2.90 |
| MSP430C413[4] | I | 64 PM | 8 kB | 256 | 48 | 1.8 - 3.6 | 96 | X | X | – | – | X | – | – | – | X | slope | $2.10 |
| MSP430F435[3] | I | 80 PN, 100 PZ | 16 kB | 512 | 48 | 1.8 - 3.6 | 160 | X | X | – | – | X | X | 1 | – | X | ADC12 | $4.40 |
| MSP430F436[3] | I | 80 PN, 100 PZ | 24 kB | 1024 | 48 | 1.8 - 3.6 | 160 | X | X | – | – | X | X | 1 | – | X | ADC12 | $4.65 |
| MSP430F437[3] | I | 80 PN, 100 PZ | 32 kB | 1024 | 48 | 1.8 - 3.6 | 160 | X | X | – | – | X | X | 1 | – | X | ADC12 | $4.85 |
| MSP430F447[3] | I | 100 PZ | 32 kB | 1024 | 48 | 1.8 - 3.6 | 160 | X | X | – | – | X | X | 2 | X | X | ADC12 | $5.65 |
| MSP430F448[3] | I | 100 PZ | 48 kB | 2048 | 48 | 1.8 - 3.6 | 160 | X | X | – | – | X | X | 2 | X | X | ADC12 | $6.40 |
| MSP430F449[3] | I | 100 PZ | 60 kB | 2048 | 48 | 1.8 - 3.6 | 160 | X | X | – | – | X | X | 2 | X | X | ADC12 | $6.95 |
| **ROM/OTP Based X3xx Family with LCD Driver** | | | | | | | | | | | | | | | | | | |
| MSP430C311S | I | 48DL | 2 kB | 128 | 11 | 2.5 - 5.5 | 64 | X | X | X | X | – | – | – | – | – | slope | $1.99 |
| MSP430P315S | I | 48DL | 16 kB | 512 | 11 | 2.7 - 5.5 | 64 | X | X | X | X | – | – | – | – | – | slope | $5.16 |
| MSP430C312 | I | 56 DL | 4 kB | 256 | 14 | 2.5 - 5.5 | 92 | X | X | X | X | – | – | – | – | – | slope | $2.40 |
| MSP430C313 | I | 56 DL | 8 kB | 256 | 14 | 2.5 - 5.5 | 92 | X | X | X | X | – | – | – | – | – | slope | $2.61 |
| MSP430C314 | I | 56 DL | 12 kB | 512 | 14 | 2.5 - 5.5 | 92 | X | X | X | X | – | – | – | – | – | slope | $2.82 |
| MSP430C315 | I | 56 DL | 16 kB | 512 | 14 | 2.5 - 5.5 | 92 | X | X | X | X | – | – | – | – | – | slope | $3.04 |
| MSP430P315 | I | 56 DL | 16 kB | 512 | 14 | 2.7 - 5.5 | 92 | X | X | X | X | – | – | – | – | – | slope | $5.16 |
| PMS430E315 | 25C | 68 FZ | 16 kB | 512 | 14 | 2.7 - 5.5 | 92 | X | X | X | X | – | – | – | – | – | slope | $99.00 |
| MSP430C323 | I | 64 PM, FN, PG | 8 kB | 256 | 14 | 2.5 - 5.5 | 84 | X | X | X | X | – | – | – | – | – | ADC14 | $5.23 |
| MSP430C325 | I | 64 PM, FN, PG | 16 kB | 512 | 14 | 2.5 - 5.5 | 84 | X | X | X | X | – | – | – | – | – | ADC14 | $5.53 |
| MSP430P325A | I | 64 PM, FN, PG | 16 kB | 512 | 14 | 2.5 - 5.5 | 84 | X | X | X | X | – | – | – | – | – | ADC14 | $6.87 |
| PMS430E325A | 25C | 68 FZ | 16 kB | 512 | 14 | 2.5 - 5.5 | 84 | X | X | X | X | – | – | – | – | – | ADC14 | $99.00 |
| MSP430C336 | I | 100 PJM | 24 kB | 1024 | 40 | 2.5 - 5.5 | 120 | X | X | X | X | X | – | 1 | X | – | slope | $6.10 |
| MSP430C337 | I | 100 PJM | 32 kB | 1024 | 40 | 2.5 - 5.5 | 120 | X | X | X | X | X | – | 1 | X | – | slope | $6.38 |
| MSP430P337A | I | 100 PJM | 32 kB | 1024 | 40 | 2.5 - 5.5 | 120 | X | X | X | X | X | – | 1 | X | – | slope | $7.53 |
| PMS430E337A | 25C | 100 PZ | 32 kB | 1024 | 40 | 2.5 - 5.5 | 120 | X | X | X | X | X | – | 1 | X | – | slope | $99.00 |

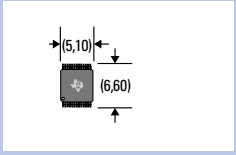
[1] I = Industrial. [2] Suggested 10,000 unit resale price in U.S. dollars. [3] Planned release Q1 2002. [4] Planned release Q2 2002.

## *Selected Package Options for MSP430 Devices*

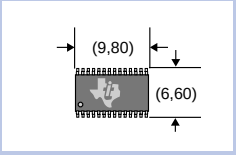
**20-pin PW (TSSOP)**



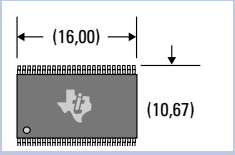

**20-pin DGV (TVSOP)**



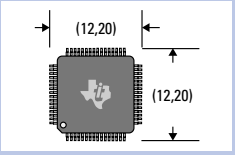

**28-pin PW (TSSOP)**



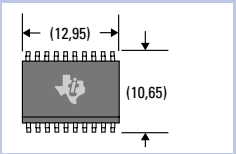

**48-pin DL (SSOP)**



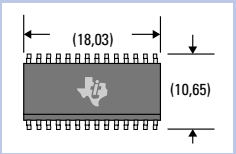

**64-pin PM (QFP)**



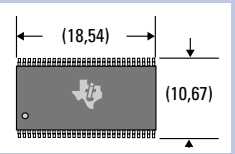

**20-pin DW (SOP)**



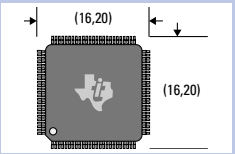

**28-pin DW (SOP)**




**56-pin DL (SSOP)**




**100-pin PZ (LQFP)**




All dimensions in millimeters.

# *TI Worldwide Technical Support*

## Internet

**TI Semiconductor Product Information Center Home Page**
www.ti.com/sc/support

**TI Semiconductor KnowledgeBase Home Page**
www.ti.com/sc/knowledgebase

## Product Information Centers

### Americas

| | |
|---|---|
| Phone | +1(972) 644-5580 |
| Fax | +1(214) 480-7800 |
| Internet | www.ti.com/sc/ampic |

### Europe, Middle East, and Africa

| | |
|---|---|
| Phone | |
| Belgium (English) | +32 (0) 27 45 55 32 |
| France | +33 (0) 1 30 70 11 64 |
| Germany | +49 (0) 8161 80 33 11 |
| Israel (English) | 1800 949 0107 |
| Italy | 800 79 11 37 |
| Netherlands (English) | +31 (0) 546 87 95 45 |
| Spain | +34 902 35 40 28 |
| Sweden (English) | +46 (0) 8587 555 22 |
| United Kingdom | +44 (0) 1604 66 33 99 |
| Fax | +(49) (0) 8161 80 2045 |
| Email | epic@ti.com |
| Internet | www.ti.com/sc/epic |

### Japan

| | | |
|---|---|---|
| Fax | International | +81-3-3344-5317 |
| | Domestic | 0120-81-0036 |
| Internet | International | www.ti.com/sc/jpic |
| | Domestic | www.tij.co.jp/pic |

### Asia

| | | |
|---|---|---|
| Phone | | |
| International | +886-2-23786800 | |
| Domestic | Local Access Code | TI Number |
| Australia | 1-800-881-011 | -800-800-1450 |
| China | 108-00-886-0015 | – |
| Hong Kong | 800-96-1111 | -800-800-1450 |
| India | 000-117 | -800-800-1450 |
| Indonesia | 001-801-10 | -800-800-1450 |
| Korea | 080-551-2804 | – |
| Malaysia | 1-800-800-011 | -800-800-1450 |
| New Zealand | 000-911 | -800-800-1450 |
| Philippines | 105-11 | -800-800-1450 |
| Singapore | 800-0111-111 | -800-800-1450 |
| Taiwan | 0800-006800 | – |
| Thailand | 0019-991-1111 | -800-800-1450 |
| Fax | 886-2-2378-6808 | |
| Email | tiasia@ti.com | |
| Internet | www.ti.com/sc/apic | |

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