

MSP430™

Development Guide Book



Rev <1.1>
<6/5/2020>

Message from the editors:

This pocket reference is intended as a valuable quick guide for all MSP430 resource. Yes, our aim is to put all we have of MSP430 in this book! That means you can call it as a MSP430 resource introduction and link entrance book. You can use this book as a MSP430 getting started guide, a self-learning book of MSP430, a dictionary to find the answers of your questions about MSP430 or a guide book when you develop applications based on MSP430. No matter the fresher or master of MSP430, they all can benefit a lot from this development guide book. If you have any comments and/or ideas for the next edition of the MSP430™ Development Guide Book, you can feedback by creating a thread in E2E, under [MSP low-power microcontroller forum](#). The latest version will be uploaded under this website: [\[FAQ\] MSP430™ Development Guide Book](#).

Revision History

Version	Date	Author	Description
1.0	5/14/2020	Eason Zhou/Maggie Zhang/Johnson He	First version
1.1	6/5/2020	Eason Zhou/Maggie Zhang/Johnson He	Add USB2ANY, fix errors

Terms and Abbreviations

Abbreviation /Term	Meaning / Explanation
FRAM	Ferroelectric RAM (FeRAM, F-RAM or FRAM)
GUI	Graphical user interface
IDE	Integrated development environment
BSL	Boot loader
DSP	Digital signal processing
JTAG	JTAG (named after the Joint Test Action Group) is an industry standard for verifying designs and testing printed circuit boards after manufacture
SBW	2-wire Spy-Bi-Wire interface, a typical JTAG interface for MSP430
MSP	Mixed Signal Processor
CapTIvate	Capacitive sensing
USS	Ultrasonic sensing
NVM	Nonvolatile memory
PC	Personal computer

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1 Overview

1.1 Overview of MSP430 series

MSP430 is a 16-bit low-power single-chip MCU launched by TI Company in 1996. At present, there are two main series based on NVM type, the Flash series and the FRAM series. For the FRAM series, it dissipates lower power and combines the characteristics of Flash and RAM. The Flash series includes MSP430x1x, MSP430x2x, MSP430x4x, MSP430x5x and MSP430x6x. The FRAM series includes MSP430FR2x, MSP430FR4x, MSP430FR5x, and MSP430FR6x. Among them, MSP430x5x6x and MSP430FR5x6x use 20bit CPU, which main frequency is higher and the internal peripherals are more abundant. The internal resources of most MSP430 series are as follows:

Table 1-1 MSP430 internal resources

Series	CPU frequency /MHz	Operating temperature /°C	NVM /KB	RAM/kB	SAR ADC resolution	GPIO Pins	I2C	SPI	UART
FRAM ⁽¹⁾	16~24	-40~85, -40~105	0.5~256	0.5~12	NA, 10bit, 12bit	12~83	NA~4	1~8	1~4
Flash	8~25	-40~85, -40~105	0.5~512	0.125~66	NA, 10bit, 12bit	4~90	NA~4	NA~8	NA~4

(1): For more description of the difference between FRAM and Flash, please refer to FRAM chapter in [Device related application notes](#)

The peripherals of MSP430 series are as follows:

Table 1-2 MSP430 peripherals

Series	Shared peripherals	Non-shared peripherals
FRAM	RTC, DMA, Watchdog, Timer, UART, SPI, I2C, LCD Controller, CRC module, AES Accelerator, 32-bit Hardware Multiplier ⁽¹⁾ , SAR ADC, DAC, Comparator, OPA(operational amplifier)	CapTIvate Module ^(1, 3) , SAC(Smart Analog Combo) ⁽¹⁾ , TIA(Transimpedance Amplifier) ⁽¹⁾ , ESI(Extended Scan Interface) ⁽²⁾ , LEA(Low-Energy Accelerator) ⁽²⁾ , USS(Ultrasonic Sensing Solution) ^(2, 3)
Flash		USB2.0 ⁽³⁾ , Sigma-Delta ADC 24bit, Sigma-Delta ADC 16bit

(1): For these MSP430 unique peripherals please refer to [MSP430FR4xx and MSP430FR2xx Family User's Guide](#).

(2): For these MSP430 unique peripherals please refer to [MSP430FR58xx, MSP430FR59xx, and MSP430FR6xx Family User's Guide](#).

(3): For these MSP430 unique peripherals please refer to [Typical MSP430 reference design](#) chapter.

1.2 MSP430 ecosystem

MSP430 ecosystem is composed of TI web resources, PC software tool resources, embedded resources and MSP430 application resources. This manual is also based on the four topics. For MSP430 beginners, simplified ecosystem map is a good reference. For MSP430 skilled users, please refer to complete ecosystem map.

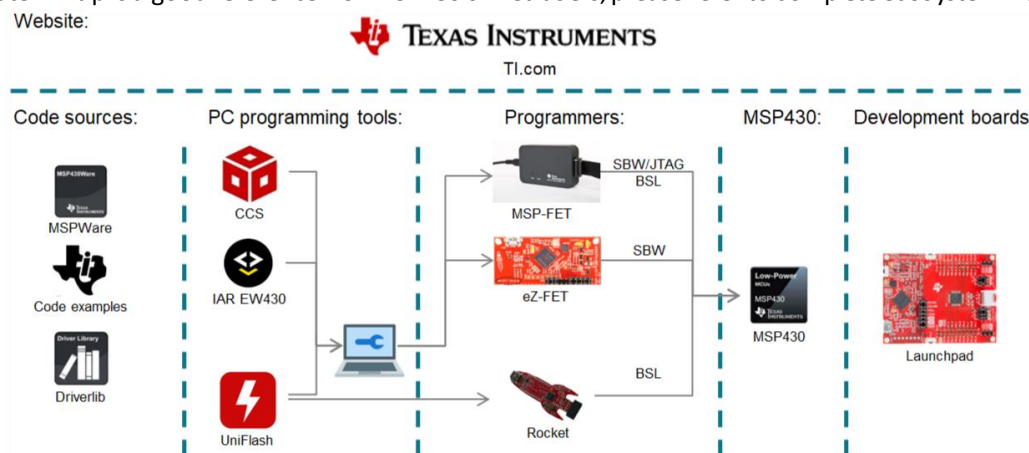


Figure 1-1 MSP430 simplified ecosystem map

Website:

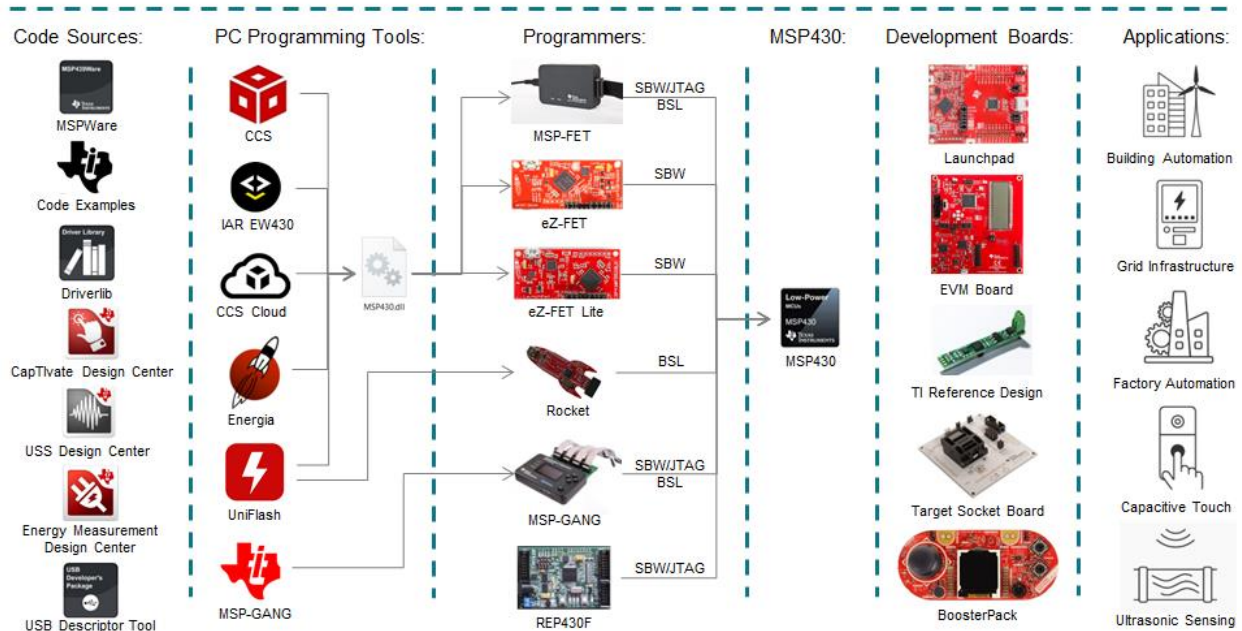


Figure 1-2 MSP430 complete ecosystem map

- **TI web resources:** TI.com contains all MSP430 related resource and information, including software tools, programmers, development boards, etc. In addition, the E2E forum provides a place for online support, discussion and knowledge sharing.
- **PC software tool resources:** TI and third parties currently provide a variety of PC-side software development tools around MSP430, including IDE, programming software, GUI for specific applications, etc.
- **Embedded resources:** It includes technical documentation, code examples, debuggers, programmers and development boards for developing or evaluating application designs related to MSP430.
- **MSP430 application resources:** TI provides device related application notes, systematic solutions, security and quality instructions to help customer better use MSP430. For systematic solutions, it will include principle description, supporting software, hardware design, test information, which can also guide users to develop related projects.

For the start of MSP430 development, we advise you to refer to [MSP430 Design Workshop Student Guide](#). It will mostly introduce MSP430 development chain, MSP430 and its peripherals with detail explanation.

1.3 Quick link to frequent questions

1. [How to find a suitable MSP430 and related resource?](#)
2. [Where to get online training and support?](#)
3. [What about the PC software tools to programming MSP430?](#)
4. [Where to get MSP430 code examples?](#)
5. [Where to find the description of MSP430 spec and usage?](#)
6. [What about the MSP430 programming tools?](#)
7. [What about the MSP430 development boards?](#)
8. [Where to find the usage of MSP430 peripherals?](#)
9. [Where to find the resource of USS, CapTivate, USB and Energy Measurement resources?](#)
10. [How to solve quality issues?](#)

2 TI web resources

2.1 TI.com overview

2.1.1 [TI.com](#) introduction

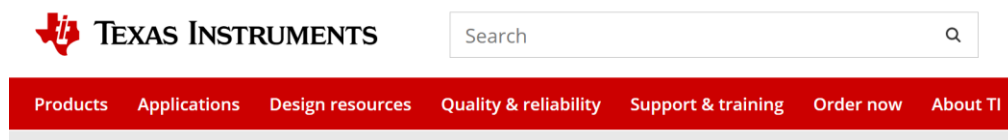


Figure 2-1 TI.com

- **Products★**: Including TI's current various types of products, which is convenient for customers to browse and choose according to their needs.
- **Application**: The mainstream market solution provided by TI, and includes related mature chip recommendations for those application designs.
- **Design resource**: The materials needed when developing products using TI device, including software and simulation tools, reference designs, product codes, hardware symbols and packaging.
- **Quality & reliability**: Include quality policy, standards and certifications.
- **Support & training**: Include online support, visualization and graphic training materials.
- **Order now**: TI's product order entry. User can buy directly on TI.com or from TI a authorized agents.
- **About TI**: TI company profile, corporate culture, social responsibility, etc.

2.1.2 [TI Cloud Tools](#)

TI Cloud Tools is a TI online tool website, which provides a wealth of tools, documents, programs, GUI and other resources. In this website, you can see the following featured sections:

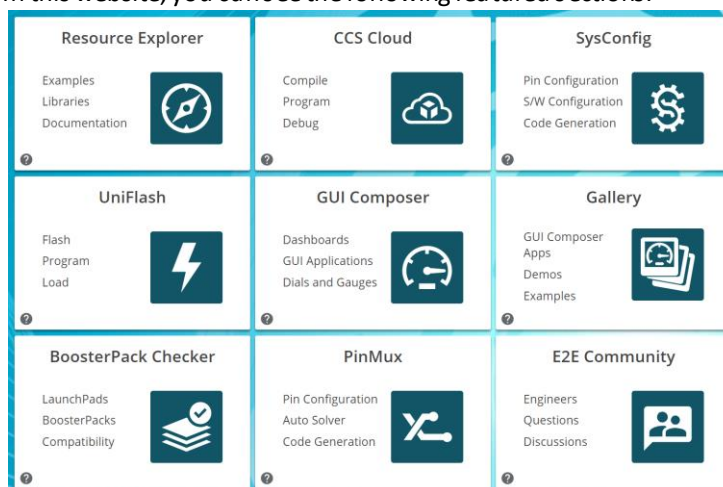


Figure 2-2 TI Cloud tools

- **Resource Explorer★**:
 - Development Tools: Development tools for TI products.
 - Device Documentation: Related documents for MSP430 and other chips (User's Guide & Datasheet & Errata).
 - Software: Enter MSP430Ware to find TI's rich software resources, there are include but not limited to example code for register level and library function versions, software driver libraries.

- **CCS Cloud:** Online CCS tool, which can help quickly debug programs online.
- **SysConfig:** Visual editing method to configure MCU internal resources. (MSP430 is not supported)
- **UniFlash:** Online programming tools and support view MCU internal information and memory data.
- **GUI Composer:** Online tool for creating a user-defined interface that interacts with the user's hardware.
- **Gallery:** GUI projects shared by users.
- **BoosterPack Check:** Helps to check whether the pins of Launchpad and BoosterPacks match.
- **PinMux:** Visual pin function assignment. (MSP430 is not supported)
- **E2E Community★:** E2E community entrance for development engineers.

2.1.3 Online support

- [TI Training](#)

TI Training provides a wealth of technical training videos, which will give an in-depth explanation of the overall or specific technologies. Full use the search bar can help you find the related resource quickly. For MSP430, you can go to [MSP430 Workshop Series](#) directly.

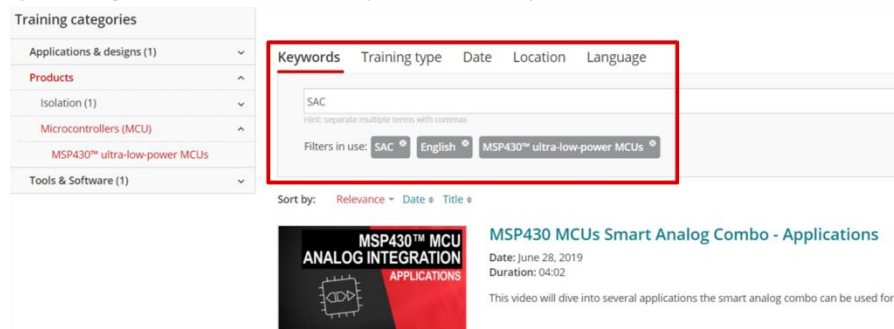


Figure 2-3 TI training

- [E2E Community](#)

E2E is TI's online technical support service platform for development engineers. There are many TI's related product experts and community technologists participate in the technical discussion. Any technical problems in the product development process can be submitted on the platform. You can also share debugging experience or related knowledge in E2E.

E2E is also an open communication platform. Enter the user's home page, you can view the discussion content and technical articles related to the user. E2E also supports chat methods with friends' private messages.

Here are four main sections in E2E:

Welcome to the TI E2E™ support forums

TI E2E support forums are an engineer's go-to source for help throughout every step of the design process. Our engineers answer your technical questions and share their knowledge to help you quickly solve your design issues.

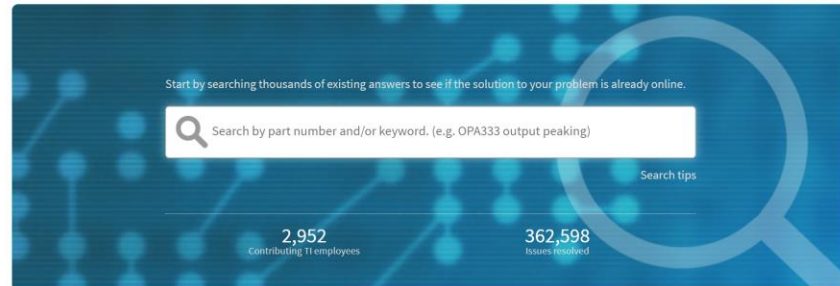


Figure 2-4 E2E Community

- **Forums:** TI products are subdivided to help development engineers to consult technical questions within a smaller product range.
- **Technical articles:** contains technical information and debugging experience shared by community members, which can help you query and share relevant technical development experience.
- **TI training:** TI training website entrance, which provides a wealth of technical training videos.
- **Getting started★:** a list of FAQs for specific tasks in E2E in the approximate order.

2.2 MSP430 web resources

2.2.1 MSP430 home page

On TI.com, select **Products->Microcontroller->MSP430 ultra-low-power MCUs** path to easily enter the MSP430 home page, or directly enter through the following URL: [Ti.com/msp430](https://www.ti.com/msp430)



Figure 2-5 Categories in MSP430 home page

In the MSP430 home page, there are seven categories:

- **Overview:** The overall introduction of MSP430, including MSP430 product features, performance, and typical resource modules.
- **Products:** All kinds of MSP430 MCU products which can be chosen according to customer needs.
- **Applications:** Application solutions for various popular markets, including but not limited to: building automation, network infrastructure, factory automation and other applications.
- **Reference designs:** Reference design related to MSP430 provided by TI. Detailed information about hardware, software, and documentation for each reference design can be easily.
- **Design & development:** The materials needed when developing MSP430 products, including debugger (MSP-FET), Launchpad, evaluation boards, IDE development tools and GUI.
- **Capacitive sensing:** Development columns for capacitive touch application products, including but not limited to capacitive touch principles, related MSP430 products and applications.
- **Ultrasonic sensing:** Development column for ultrasonic application products, including but not limited to the introduction of ultrasonic solution in water meters, gas meters market.

2.2.2 MSP430 product page

Every MSP430 has a product page, as shown below (Using MSP430FR2311 as an example). There is some basic information of the product (operating frequency, memory size, peripheral resources), and provides some important files for easy reference and download: Datasheet, User Guide and Errata. You can also find other related information on this page.

Home / Microcontrollers (MCU) / MSP430 ultra-low-power MCUs

Subscribe to updates

MSP430FR2311 ACTIVE

Order now

16MHz integrated analog microcontroller with 3.75KB FRAM, Op-Amp, TIA, Comparator w/ DAC, 10-bit ADC

[DATA SHEET](#) [MSP430FR2311x Mixed-Signal Microcontrollers datasheet \(Rev. E\)](#) | [Online data sheet](#)

USER GUIDES

ERRATA

[MSP430FR4xx and MSP430FR2xx Family User's Guide \(Rev. I\)](#)

[MSP430FR2311 Device Erratasheet \(Rev. P\)](#)

Figure 2-6 MSP430 product page

The product page also provides many important resources for reference:

[Product details](#) | [Technical documentation](#) | [Design & development](#) | [Ordering & quality](#) | [Support & training](#)

Product details

[Parameters](#) | [Package | Pins | Size](#) | [Features](#) | [Description](#)

Features	OpAmp, Real-Time Clock, Transimpedance amplifier
Non-volatile memory (kB)	4
RAM (kB)	1
ADC	10-bit SAR
ADC: channels (#)	8
GPIO pins (#)	16
I2C	1
SPI	2
UART	1
Comparator channels (#)	2

[View all](#)

[Find other MSP430 ultra-low-power MCUs](#)

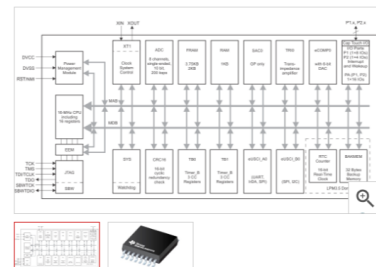


Figure 2-7 MSP430 product page

- **Product details:** It includes product details, feature descriptions, internal resource structure block diagram, etc, which can help understand general performance of the product and internal resources.
- **Technical documentation:** Rich technical documentation related to this MSP430 part device, including but not limited to: application manuals, technical articles, example code and other resources.
- **Design & development:** Design kits and hardware evaluation boards including but not limited to: product-related reference designs, software, development tools, CAD / CAE symbols and other resources.

2.2.3 MSP430 device selection

MSP430 has a large portfolio. Today, there are about 560 MSP430 devices on TI.com. Here are three ways to find the suitable MSP430 through TI.com.

- Through [MSP430 product search page](#)★

Enter the on chip resources your needs in the MSP430 product search page on the MSP430 home page. Using **quick search** tool, you can quickly found MSP430 device that meet basic requirements. In addition, you can use the **filter bar** on the left for accurate search.

Table 2-7 MSP430 peripherals

Part	FRAM	RAM	ADC Type	GPIO	Package	Features	UART	SPI	I2C	Comparator	Price
MSP430xx	-KB	-KB	SAR/SD	-	-	-	-	-	-	-	-

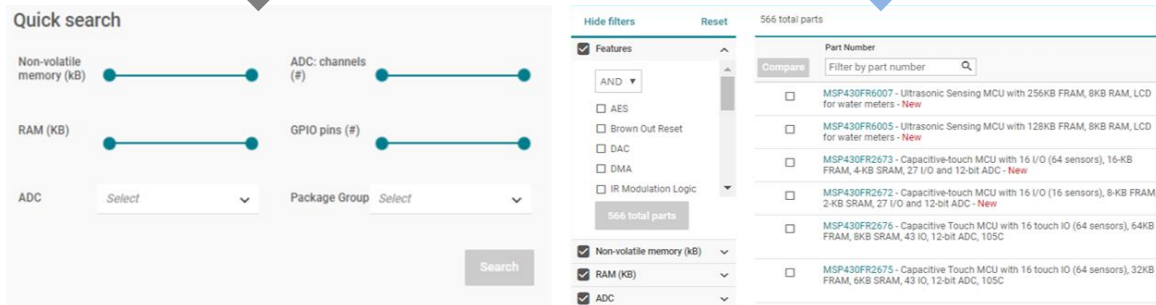


Figure 2-8 MSP430 search

We also have some MSP430 for typical application like space, military, enhanced products, and high temperature applications. For these devices, please choose the related rating.

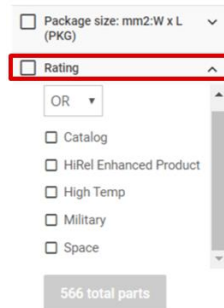


Figure 2-9 different rating

- Through reference designs
On the [Reference designs page](#), TI provides a systematic solution. Select the market type or use filter by keywords. It will show a wealth of reference designs using MSP430. Besides, users can obtain key document, software, hardware, BOM and other materials for every reference design.

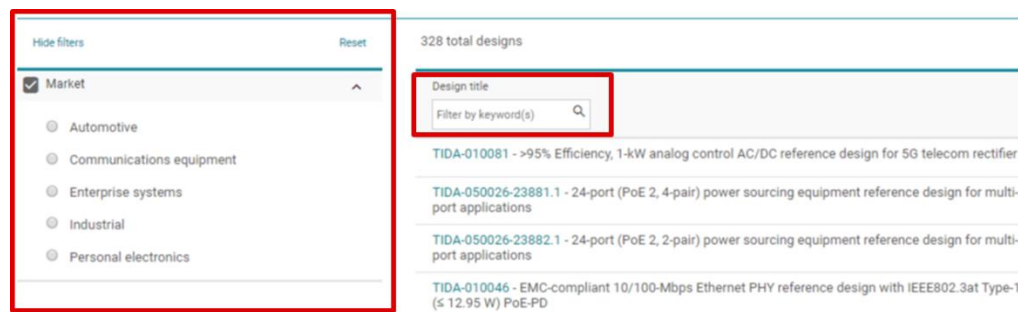


Figure 2-10 MSP430 reference designs

- Through typical MSP430 applications


On the [Application page](#), TI provides some mainstream market applications and design solutions for end product, and includes related mature chip recommendations for selection.

Building security systems

Access control

Add capacitive touch to your security system keypad and electronic smart lock designs with MSP430 capacitive sensing microcontrollers. Leverage a broad portfolio that can scale with your needs - from discrete touch solutions to SoCs for more system control.

Design challenge	MSP430 advantages & benefits
Energy efficiency / long battery life	Benchmark performance for standby current consumption
Small form factor and board size	Flexible sensor/button design for small board space
Resistance to harsh elements/environments	IPX5-rated solutions for water/moisture rejection
RF noise immunity	Spread spectrum modulation and frequency hopping techniques to reduce antenna interference
Time to market	Real-time tuning and code generation with CapTivate Design Center



Featured devices	Tools and development kits	Design resources
MSP43FR2676	CapTivate Design Center GUI	Application note: CapTivate Design Flow Guide
MSP430FR2533	MSP430 CapTivate Touch Keypad BoosterPack	Reference design: Liquid Tolerant Capacitive Touch Keypad
MSP430FR2522	MSP430FR2676 MCU board	Reference design: CapTivate Electronic Lock and Keypad
		Reference design: Access Control Panel with Capacitive Touch and BLE

Figure 2-11 MSP430 application

3 PC software tool resources

3.1 Programming related software

Here is the contrast between different MSP430 programming tools. For MSP-GANG programmer, it only supports MSP-GANG hardware. For other Command line tools like MSPflasher or BSLscripter, they have already been combined into UniFlash.

Table 3-1 Programming tools cooperation

Features	CCS	IAR	UniFlash	Energia
Edit code	√	√		√
Compile and debug	√	√		√
JTAG/SBW programming	√	√	√	√
Bootloader			√	
Windows operation system	√	√	√	√
Mac OS operation system	√		√	√
Linux operation system	√		√	√

CCS★: Code Composer Studio (CCS) is the IDE tool provided by TI, which is free of charge and also integrates TI Resource Explorer. If the MSP430 is not recognized, please try to install [MSP FET Drivers](#).

- Product page: [CCS IDE for MSP430](#)
- User's guide: [Code Composer Studio User's Guide](#)
- Guide book: [CCS Step-by-step Workshop for MSP430](#)
- Video link: [Getting Started with Code Composer Studio v9.3](#)
- Related software development user's guide:
 - [CCS documentation MSP430™ Assembly Language Tools User's Guide](#)
 - [MSP430™ Optimizing C/C++ Compiler User's Guide](#)
 - [MSP430 Embedded Application Binary Interface Application note](#)
- Useful Tools integrated into CCS:
 - [TI Resource Explorer](#): A tool contains all materials for developing MCUs and processors.
 - [EnergyTrace](#): An energy-based code analysis tool that measures and displays the energy profile of an application.
 - [ULP \(Ultra-Low Power\) Advisor](#): A tool can provide ultra-low power improvement suggestions for user's code.

IAR EW430: IAR Embedded Workbench for MSP430 (IAR EW430) is a third party IDE tool provided by IAR company.

- Product page: [IAR Embedded Workbench for MSP430](#)
- User's guide: [IAR Embedded Workbench® IDE Version 7+ for MSP430™ MCUs](#)

UniFlash★: UniFlash is a programming GUI tool developed by TI, which supports JTAG and BSL. To program MSP430, You need to load a binary file, which can be generated following this [link](#). If the MSP430 is not recognized, please try to install [MSP FET Drivers](#).

- Product page: [UniFlash](#)
- User's guide:
 - [UniFlash Quick Start Guide](#)
 - [Programming the Bootloader of MSP430™ Using UniFlash](#)

Energia: Energia is an open source & community-driven IDE. It primarily supports MSP430 which is available in the LaunchPad.

- Product page: [Energia](#)

MSP430-GCC: MSP430-GCC combines debugger and open source C/C++ compiler toolchains for building and debugging embedded applications based on MSP430 and MSP432 microcontrollers.

- Product page: [GCC - Open Source Compiler for MSP Microcontrollers](#)

MSPDS: The MSP debug stack (MSPDS) consists of a static library on the host system side as well as an embedded firmware that runs on debug tools like MSP-FET. It is open source and can be used to customize MSP430 debugging software tool.

- Product page: [MSP Debug Stack](#)

3.2 MSP430 software development kit

Offline MSP430Ware: It is a collection of resource that helps users to effectively create and build MSP430 code. It contains user manuals, code examples, and MSP430 driver libraries for MSP devices or libraries based on typical applications. It is also integrated into TI Resource Explorer, which can be found in CCS and web.

- Product page: [MSP430Ware for MSP Microcontrollers](#)
- Folder type introduction:

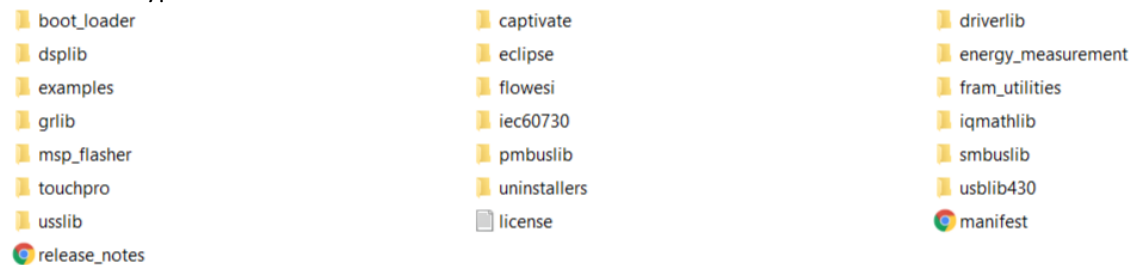


Figure 3-1 Offline MSP430Ware content

- Code examples:
 - Examples: It contains register-level code examples based on development boards and chips. Support CCS, IAR.
 - Driverlib: It contains source files, routines, and corresponding documents of the MSP430 driver library. Support CCS, IAR.
- Typical application libraries (They contain GUI, source files, code examples and related documents):
 - These folders are Captivate (CapTivate Design Center and Software Library), usslib (USSSvLib), energy_measurement (Energy Measurement Library), usblib430 (USB Developer's Package), flowesi (Linear and Rotational Motion Detection Library), grlib (Graphics Library) and Dsplib (DSPLib).
- Other application libraries (They contain source files, routines and corresponding documents):
 - These folders are iec60730 (IEC60730 Library), iqmathlib (IQmath Library), pmbuslib (PMBusLib), smbuslib (SMBusLib).
- Other types:
 - boot_loader: It contains related documents of bootloader and customized bootloader.
 - fram_utilities: It contains development routines and documentation based on the characteristics of FRAM.
 - msp_flasher: It is a MSP430 command line download software which is replaced by UniFlash and not maintained.

Online MSP430Ware: it refers to the MSP430Ware in TI Resource Explorer. The most difference between the Online and offline version is that you can find more information in Development Tools folder of online version about development tools, including IDE, programming software tools, debug probe, development

boards, etc. Besides, you can download the typical examples or documents without downloading a whole package.

- Product page: [Online MSP430Ware](#)
- Folder directory introduction:

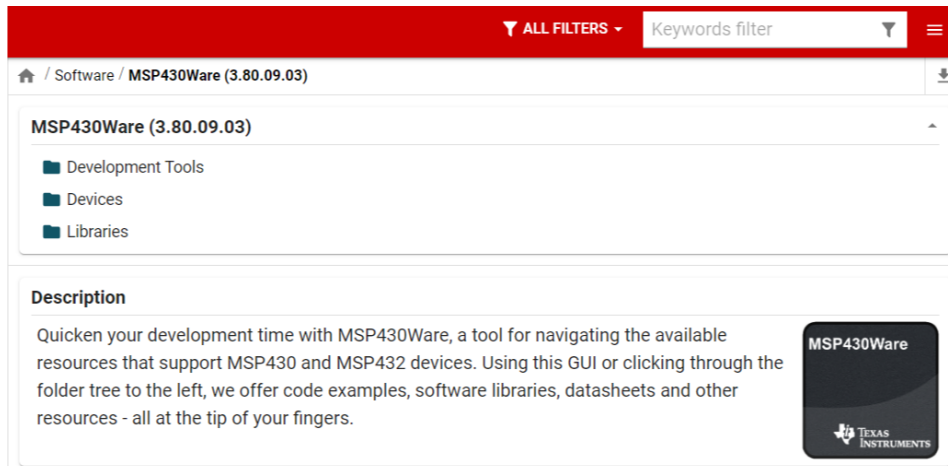


Figure 3-2 Online MSP430Ware content

- **Development tools:** Include the information of software demos or examples of IDE, programming software tool, debug probe, development boards, etc.
- **Devices:** Device family related code examples.
- **Libraries:** Different driver libraries or application libraries.

3.3 MSP430 related GUIs

In order to help customers develop some complex applications, TI has developed GUIs for these applications.

- [CapTivate™ Design Center](#): A one-stop resource for everything related to CapTivate capacitive sensing technology integrated on TI MSP430™ microcontrollers.
- [Ultrasonic Sensing Design Center](#): A one-stop resource to develop ultrasonic sensing applications using MSP430™ microcontrollers (MCUs).
- [Energy Measurement Design Center](#): A rapid development tool that enables energy measurement using TI MSP430i20xx and MSP430F67xx flash-based microcontrollers (MCUs).
- [MSP430 USB Developers Package](#): A software package containing all necessary source code and sample applications required for developing a USB-based MSP430 project.
- [FlowESI GUI for flow meter configuration using the Extended Scan Interface \(ESI\)](#): The FlowESI GUI allows user to develop configuration code for the ESI module without having to break open the User's Guide! Follow the simple graphical instructions and connect up to 3 LC sensors to the extended SCAN Interface module.
- [MSP Graphics Library](#): A royalty-free set of graphics primitives for creating graphical user interfaces on MSP430 and MSP432 microcontroller-based boards that have a graphical display. For Image Reformer Tool, it is an image size and color depth manipulation utility used in Graphics Library.
- [Digital Signal Processing \(DSP\) Library](#): A set of highly optimized functions to perform many common signal processing operations on fixed-point numbers for MSP430 microcontrollers. The DSPLib GUI can be used to design an Optimized DSP Library for MSP MCUs.

4 Embedded resources

4.1 Technical documentation

Datasheet★: This paper introduces the parameters and functional data information of various MSP430, including pin function, performance parameters of its peripherals and MSP430 itself, internal signal connection, physical characteristics, product packaging and packaging, product assembly graphic parameters, etc. It is the basic reference document for typical MSP430 device.

- Please download the document on the corresponding [MSP430 product page](#).

Family user's guide★: It mainly introduces the application method and characteristic of MSP430, including but not limited to the abstract model of CPU and peripherals, working mode and corresponding register configuration method.

- Flash series:
 - [MSP430x1xx Family User's Guide](#)
 - [MSP430x2xx Family User's Guide](#)
 - [MSP430i2xx Family User's Guide](#)
 - [MSP430x4xx Family User's Guide](#)
 - [MSP430x5xx and MSP430x6xx Family User's Guide](#)
- FRAM series:
 - [MSP430FR4xx and MSP430FR2xx Family User's Guide](#)
 - [MSP430FR57xx Family User's Guide](#)
 - [MSP430FR58xx, MSP430FR59xx, and MSP430FR6xx Family User's Guide](#)

Errata★: It is aimed at the corrigendum description of MSP430 related series or versions in some application scenarios, functions or parameters. Besides, it describes the phenomena, causes and solutions. It should be used with datasheets during MSP430 product development.

- Please download the document on the corresponding [MSP430 product page](#).

Application note: Technical document about device, device peripherals or applications, which is the most common type of technical documentation you can see on TI.com.

White paper: General introduction about device, device peripherals or applications.

Technical article: Describe device, device peripherals or applications in a blog form. Its content will be short and flexible.

- Home page: [Embedded processing](#)

4.2 Embedded software

MSP430 code examples★: MSP430 code examples are self-contained low-level programs that typically demonstrate a single peripheral function or device feature in a highly concise manner, written in C or assembly. It supports both CCS and IAR IDE.

- Product page: Please go through Design & development in [MSP430 product page](#) of typical MSP430 device.

MSP Driver Library: It contains software APIs that abstract away the details of the device's hardware registers, examples showing how to use DriverLib APIs in your project. It supports both CCS and IAR IDE. Using Driverlib will be easy to develop large project, but at the expense of efficiency.

- Product page: [MSP Driver Library](#)

MSP430™ Value Line Sensing Function Code Examples: It is a collection of 25 code examples using MSP430FR2xxx. These code examples allow developers to add programmability to simple digital and analog functions, such as timers, input/output expanders, system reset controllers, EEPROM and more.

- Product page: [MSP430™ Value Line Sensing Function Code Examples](#)

Other software libraries: For other libraries, please refer to [MSP430 software development kit](#) chapter.

TI-RTOS: TI-RTOS is a real-time operating system for TI microcontrollers, which is free of charge. The latest version for MSP430 is 2.20.00.06 (22 Jun 2016). There is no plan for update till now. We strongly advise you to use no-RTOS on MSP430.

- Product page: [TI-RTOS Product Releases and Download Links](#)

FreeRTOS: FreeRTOS is a market-leading RTOS. Distributed freely under the MIT open source license, it includes a kernel and a growing set of libraries suitable for use across all industry sectors.

- Product page: [FreeRTOS](#)

4.3 Debuggers and programmers

Here is the contrast between different MSP430 programmer tools advised by TI and the contrast between different programming ways.

Table 4-1 Debugger and programmer tools contrast

Features	eZ-FET	MSP-FET	eZ-FET Lite	MSP-FET430UIF	MSP-GANG	REF430F	Rocket
Type	Debugger	Debugger	Debugger	Debugger	Programmer	Programmer	Programmer
4-wire JTAG		√		√	√	√	
2-wire JTAG(SBW)	√	√	√	√	√	√	
BSL tool or mode		√			√		√
USB Backchannel UART	√	√					
Supported by CCS / IAR	√	√	√	√			
Supported by UniFlash	√	√	√	√			√
EnergyTrace	√	√					
Application	Development	Development	Development	Development	Production	Production	Firmware update

Table 4-2 Debug and programming ways contrast

Features	SBW	JTAG	BSL	Main memory BSL
Debug	√	√		
Program	√	√	√	√
Programming Pin	2	4	2~3	2~3
Invoke Pin(RST, TEST)	√	√	√	
Protocol	2-wire JTAG	4-wire JTAG	UART/SPI/I2C/USB	UART/SPI/I2C/USB
Advantages	Need few pins/trace than JTAG	Stable and faster than SBW	Simplest programming interface	Support customized BSL

Debugger (Debug probe): It mainly refers to the powerful emulation development tools that support all MSP430 JTAG and SBW debugging interfaces, which can be used for debug and program. Please note that CCS9 only supports four debuggers, eZ-FET, eZ-FET Lite, MSP-FET, and MSP-FET430UIF.

Programmer: It refers to these products made for only programming. It mainly includes MSP-GANG and Rocket.

- User's guide★:
 - [MSP Debuggers User's Guide](#)
- Related products:
 - **MSP-FET★**: It is the most powerful and fastest MSP430 debug probe. Target VCC is selectable and the maximum supply current is 100 mA.

- Product page: [MSP-FET MSP MCU Programmer and Debugger](#)
- **eZ-FET★**: It is a low-cost MSP430 debug probe and usually sold with LaunchPad. Besides, it only supports a fixed voltage power supply.
 - Product page: Please refer to the specific Launchpad product page.
- **eZ-FET Lite**: It is a low-cost MSP430 debug probe and usually sold with LaunchPad, which removes EnergyTrace from eZ-FET. It is also an open source debug probe for customer to customize their own debug probe.
 - Product page: Please refer to [MSP430F5529 LaunchPad kit](#) product page.
 - Open source version entrance: [MSP430_ezFETLite](#)
- **MSP-GANG★**: The MSP Gang Programmer can't debug code and is used for product production. It can be operated without PC and supports programming eight MSP430 at the same time.
 - Product page: [MSP-GANG Production Programmer](#)
- **Rocket★**: It is cooperated with UniFlash and mostly used for downloading and erasing. TI provides source code and hardware design.
 - Product page: [MSPBSL_Rocket](#)
- **REF430F**: It is an open source product production tool, which is used for customer to customize, which can be used to learn JTAG communication protocol.
 - Product page: [Elprotronic, Inc. Replicator for MSP430 MCU](#)
 - User's guide: [MSP430 Programming With the JTAG Interface](#)
- **MSP-FET430UIF**: It is a previous generation of MSP-FET, which you can't buy anymore on TI.com nowadays.
 - Product page: [MSP-FET430UIF](#)
- **EnergyTrace**: It is an energy-based code analysis tool that measures and displays the energy profile of an application, including software and hardware part. For software part, it is integrated in CCS and IAR.
 - Product page: [EnergyTrace Technology](#)
 - User's guide: [ULP Advisor™ Software and EnergyTrace™ Technology](#)
- **USB2ANY interface adaptor**: a tool intended to allow a computer to control an evaluation module (EVM) via a USB connection, which supports multiple popular protocol interfaces.
 - Product page: [USB2ANY interface adaptor](#)
 - User's guide: [USB2ANY Interface Adapter User's Guide](#)

Bootloader(BSL): It points to the software upgrade program that is stored into Flash or ROM before the factory. It is mainly used for code programming, erasing and reading in RAM, main memory and information memory. During software upgrade, the occupied I/O pins are the communication interface, RST and TEST pins. For supported communication methods, please refer to Bootloader (BSL) chapter in the related MSP430's datasheet.

- Customized BSL Type:
 - **Flash-Based BSL (Support MSP430F5x and MSP430F6x)**: TI provides BSL source code in Bootloader (BSL) memory, but it is limited by storage space and less flexibility.
 - **Main Memory BSL (Support all MSP430)**: TI provides example code of Main Memory BSL for customers to develop customized BSL, which is in main memory and more flexibility but requires additional storage space.
- Product page: [Bootloader \(BSL\) for MSP low-power microcontrollers](#)
- Video:
 - [MSP Bootloader \(BSL\) Overview](#)

- [MSP Bootloader \(BSL\) Options](#)
- User's guide:
 - [MSP430™ Flash Devices Bootloader \(BSL\) User's Guide](#)
 - [MSP430 FRAM Devices Bootloader \(BSL\) User's Guide](#)
- Application notes:
 - [Creating a Custom Flash-Based Bootloader \(BSL\)](#)
 - [Launchpad-Based MSP430 UART BSL Interface](#)
 - [MSP430 Bootloader With SimpleLink MCUs](#)
 - [MSP430 Bootloader With Sitara Embedded Linux Host](#)
 - [MSP430 Firmware Updates over I2C using Linux](#)
 - [MSPBoot – Main Memory Bootloader for MSP430 Microcontrollers](#)
 - [MSP430FRBoot – Main Memory Bootloader and Over-the-Air Updates](#)
 - [Over-the-Air \(OTA\) Update With the MSP430FR57xx](#)

4.4 Development boards

Table 4-3 Development boards contrast

Features	Launchpad	EVM board	Target socket board	TI reference design	BoosterPack
eZ-FET on board	√	√ / X			
Pinout	√	√ / X	√		√
Board on sale	√	√	√		√
Board features	Ease to use and cheap	Systematic solution	Socket on board	Systematic solution	Compatible with LaunchPad
Application	Learning or evaluating MSP430	Typical MSP430 application reference	Chip test/Sub system reference	End equipment reference	Build a system with analog and digital device fastly

Launchpad★: It is a Low-cost MSP430 development board developed by TI, which integrates onboard debugger. It has fewer peripheral devices but leads out most MSP430 pins. Different Launchpad can be plugged together to develop a more completed system. It is the first choice for developing MSP430 applications.

- Product page: [MSP430FR2355 LaunchPad kit](#)
- Product page: [MSP430FR2433 LaunchPad kit](#)
- Product page: [MSP430FR2311 LaunchPad kit](#)
- Product page: [MSP430FR4133 LaunchPad kit](#)
- Product page: [MSP430FR5994 LaunchPad kit](#)
- Product page: [MSP430FR6989 LaunchPad kit](#)
- Product page: [MSP430FR5969 LaunchPad kit](#)
- Product page: [MSP430F5529 LaunchPad kit](#)
- Product page: [MSP430G2x LaunchPad kit](#)
- Product page: [MSP430FR2476 LaunchPad kit](#)

Target socket board: it is a standalone ZIF socket target board used to program and debug through the JTAG and BSL. There are no peripheral devices on board but it leads out all MSP430 pins. The most advantage is that it covers all MSP430 series and MSP430 chip on board is detachable.

- User's guide★: [MSP430 Hardware Tools User's Guide](#)
- Product page: See the Design & Development column of each [MSP430 product page](#).

EVM board: It is an evaluation board mainly developed for typical MSP430 applications, such as CapTivate sensing, USS sensing, energy measurement, etc. It contains related document, software source code, and hardware. It provides a reference for customers to develop typical MSP430 applications.

- Product list: [MSP430 EVM boards](#)

TI reference design (Reference design / TI design): It is developed for applications using MSP430, such as energy measurement, power, motor control, etc. It contains full design resources and most is a reference for developing end equipment. It is very like EVM board, the difference is that it is not on sale and has less materials.

- Product page: [MSP430 ultra-low-power MCUs – Reference designs](#)

BoosterPack: BoosterPack™ plug-in module is a platform for learning and evaluating the Analog or digital devices, provided by TI. It now has 53 types and almost covers all TI product series. The BoosterPack form factor is compatible with the TI LaunchPad™ ecosystem of hardware evaluation modules.

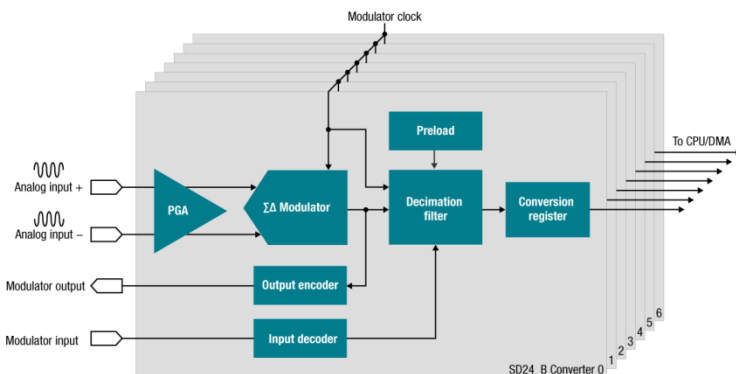
- Product list: [BOOSTXLseries product list](#)
- User's guide: [Build Your Own LaunchPad™ or LaunchPad BoosterPack™ Development Tool](#)

5 MSP430 application resources

5.1 Device related application notes

This part lists all the application notes based on MSP430 and its peripherals.

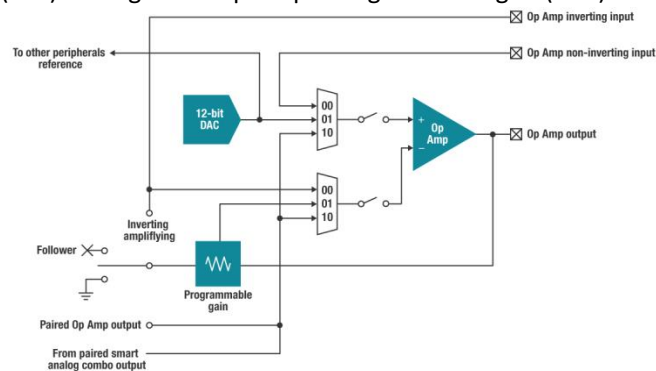
- Coding, programming and debugging:
 - [Software Coding Techniques for MSP430™ MCUs](#)
 - [MSP Code Protection Features](#)
 - [Understanding MSP430 Flash Data Retention](#)
 - [Mixing C and Assembler With MSP430™ MCUs](#)
 - [Design Considerations When Using the MSP430 Graphics Library](#)
 - [Optimizing C Code for Size With MSP430 MCUs: Tips and Tricks](#)
 - [Debugging Flash Issues on the MSP430 Family of Microcontrollers](#)
- Oscillator:
 - [MSP430 32-kHz Crystal Oscillators](#)
 - [MSP430 LFXT1 Oscillator Accuracy](#)
- ADC:



Picture 5-1 Seven channel Sigma-Delta ADC diagram

- [A Glossary of Analog-to-Digital Specifications and Performance Characteristics](#)
- [ADC Wake and Transmit on Threshold Using MSP430™ MCUs](#)
- [Designing With the MSP430FR4xx and MSP430FR2xx ADC](#)
- [Designing With the MSP430FR58xx, FR59xx, FR68xx, and FR69xx ADC](#)
- [General Oversampling of MSP ADCs for Higher Resolution](#)
- [High-Speed, Analog-to-Digital Converter Basics](#)
- [How delta-sigma ADCs work, Part 1](#)
- [How delta-sigma ADCs work, Part 2](#)
- [Implementing a Thermocouple Interface With ADC12 A](#)
- [Low-Power Battery Voltage Measurement With MSP430FR MCU On-Chip VREF and ADC](#)
- [Oversampling the ADC12 for Higher Resolution](#)
- Communication:
 - [Understanding the I2C Bus](#)
 - [Implementing a UART Function with the 8-bit Interval Timer/Counter](#)
 - [SPI I/O Expander Using Low-Memory MSP430™ MCUs](#)
 - [UART Software Controlled RGB LED Color Mixing With MSP430™ MCUs](#)
 - [UART-to-I2C Bridge Using Low-Memory MSP430™ MCUs](#)

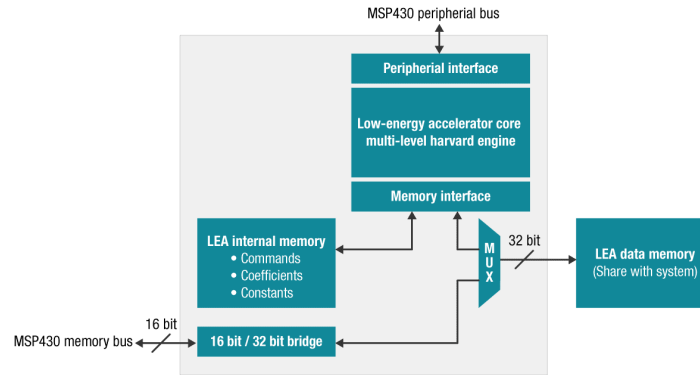
- [UART-to-SPI Bridge Using Low-Memory MSP430™ MCUs](#)
- [UART-to-UART Bridge Using Low-Memory MSP430™ MCUs](#)
- [Enabling Low-Power Windows 8 HID Over I2C Applications Using MSP430 MCUs](#)
- [Implementing SMBus Using MSP430 Hardware I2C](#)
- [Software I2C on MSP430 MCUs](#)
- [Solutions to Common eUSCI and USCI Serial Communication Issues on MSP430 MCUs](#)
- [Using the USCI I2C Master](#)
- **FRAM:**
 - [FRAM FAQ](#)
 - [EEPROM Emulation Using Low Memory MSP430™ FRAM MCUs](#)
 - [Maximizing Write Speed on the MSP430™ FRAM](#)
 - [MSP430 FRAM Quality and Reliability](#)
 - [MSP430 FRAM Technology – How To and Best Practices](#)
- **PWM:**
 - [Analog Input to PWM Output Using the MSP430™ MCU Enhanced Comparator](#)
 - [Dual-Output 8-Bit PWM DAC Using Low-Memory MSP430™ MCUs](#)
 - [PWM DAC Using MSP430 High-Resolution Timer](#)
 - [Using PWM Timer_B as a DAC](#)
- **RTC:**
 - [External RTC With Backup Memory Using a Low-Memory MSP430™ MCU](#)
 - [Simple RTC-Based System Wake-up Controller Using MSP430™ MCUs](#)
 - [ULP Temperature-Compensated RTC on MSP430F6736](#)
 - [Using the MSP430 RTC_B Module With Battery Backup Supply](#)
 - [Using the Real-Time-Clock Library](#)
- **Timer:**
 - [External Programmable Watchdog Timer Using MSP430™ MCUs](#)
 - [Multiple Time Bases on a Single MSP430 Timer Module](#)
 - [Using the MSP430 Timer_D Module in Hi-Resolution Mode](#)
- **Smart analog combo(SAC): Configurable Op-Amp + Programmable gain(PGA) + 12-bit DAC**



Picture 5-2 Smart analog combo diagram

- [Half-wave rectifier circuit with MSP430 smart analog combo](#)
- [High-side current-sensing circuit design with MSP430 smart analog combo](#)
- [How to Use the Smart Analog Combo and Transimpedance Amplifier on MSP430FR2311](#)
- [How to Use the Smart Analog Combo in MSP430™ MCUs](#)
- [Low-noise long-range PIR sensor conditioner circuit MSP430 smart analog combo](#)

- [Low-side bidirectional current sensing circuit with MSP430™ smart analog combo](#)
- [Strain gauge bridge amplifier circuit with MSP430 smart analog combo](#)
- [Temperature Sensing NTC Circuit With MSP430 Smart Analog Combo](#)
- [Transimpedance amplifier circuit with MSP430 smart analog combo](#)
- [Single-supply low-side unidirectional current-sensing circuit with MSP430 SAC](#)
- Low-energy accelerator (LEA): Hardware engine designed for operations that involve vector-based signal processing without CPU intervention.



Picture 5-3 Low-energy accelerator diagram

- [Benchmarking the Signal Processing Capabilities of the Low-Energy Accelerator](#)
- [Low-Energy Accelerator \(LEA\) Frequently Asked Questions \(FAQ\)](#)
- LCD:
 - [Designing With MSP430™ MCUs and Segment LCDs](#)
 - [Driving Large LCDs with LCD Peripheral of the MSP430](#)
 - [Software Glass LCD Driver Based on MSP430 MCU](#)
 - [Use of Two MSP430s to Enhance Segment Lines for Larger LCDs](#)
- Migrating from Flash to FRAM series:
 - [Code Porting From MSP430FR2000 to MSP430FR2311 MCUs](#)
 - [Migrating From MSP430FW42x Scan Interface to MSP430FR6x8x/FR5x8x ESI](#)
 - [Migrating from MSP430 F2xx and G2xx families to MSP430 FR4xx and FR2xx family](#)
 - [Migrating from the MSP430F2xx Family to the MSP430FR57xx Family](#)
 - [Migrating from the MSP430F2xx, G2xx Family to the MSP430FR58xx/FR59xx/68xx/69xx](#)
 - [Migrating From MSP430F4xx Family to MSP430FR58xx/FR59xx/FR68xx/FR69xx Family](#)
 - [Migrating from the MSP430F4xx to Family to the MSP430FR4xx Family](#)
 - [Migrating from the MSP430F5xx, F6xx Family to the MSP430FR58xx/FR59xx/68xx Family](#)
 - [Migrating from the USCI Module to the eUSCI Module](#)
 - [Migration from MSP430 FR58xx, FR59xx, and FR6xx to FR4xx and FR2xx](#)

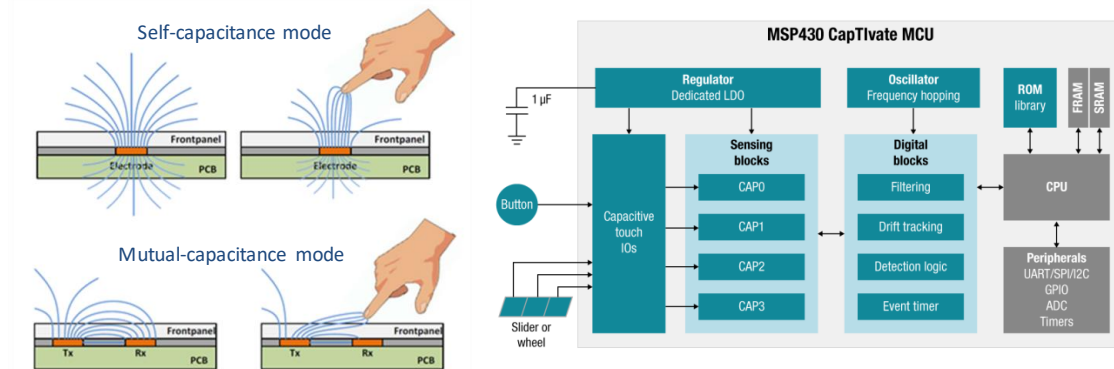
5.2 Systematic solutions

For this part, we have three chapters. Typical MSP430 reference design chapter introduces the target application of MSP430, which will have GUI and abundant materials. TI design chapter introduces the applications with sufficiently materials. In Application notes chapter, the designs described in application notes will have a wider application range.

5.2.1 Typical MSP430 reference design

5.2.1.1 Capacitive touch sensing

This technology provides a low-power capacitive touch solution, which supports buttons, sliders, wheels and proximity. For touchpad materials, it supports metal, glass, plastic, etc. It is mostly used to improve the aesthetics and reliability of human-computer interaction.



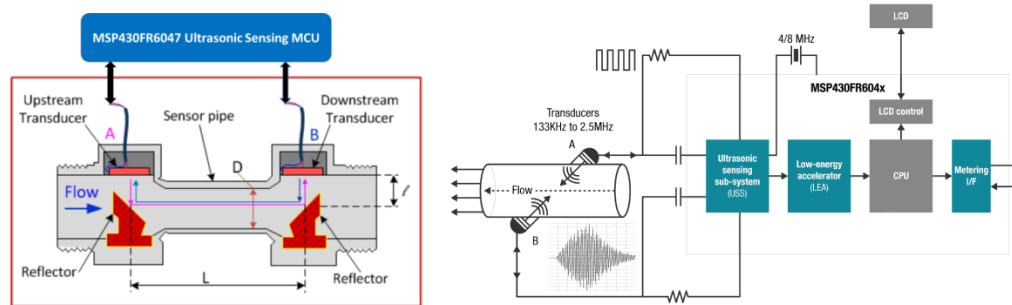
Picture 5-4 Capacitive touch sensing diagram

- Product page: [CapTivate™ MCUs: Easiest to use capacitive touch solutions](#)
- GUI product page: [CapTivate™ Design Center GUI](#)
- User's guides★:
 - [CapTivate™ Technology Guide](#)
- Video series: [CapTivate™ Technology Training Series](#)
- Design flow guides★:
 - [Capacitive Touch Design Flow for MSP430™ MCUs With CapTivate™ Technology](#)
- EVM and other boards on sale:
 - [CAPTIVATE-PGMR](#) (eZ-FET™ Programmer/debugger)
 - [CAPTIVATE-FR2676](#) (MSP430FR2676 Target MCU module)
 - [CAPTIVATE-FR2633](#) (MSP430FR2633 Target MCU module)
 - [BOOSTXL-CAPKEYPAD](#) (MSP430FR2522 + Mutual Capacitive HMI Demo)
 - [EVM430-CAPMINI](#) (MSP430FR2512 + Self capacitance Demo)
 - [CAPTIVATE-ISO](#) (Program and Communication Isolator)
 - [CAPTIVATE-BSWP](#) (Self capacitance HMI demo panel)
 - [CAPTIVATE-PHONE](#) (Mutual capacitance HMI demo panel)
 - [CAPTIVATE-METAL](#) (Metal Touch HMI demo panel)
 - [CAPTIVATE-EMC](#) (Electromagnetic compatibility performance evaluation)
- Application notes:
 - [Enabling noise tolerant capacitive touch HMIs with MSP CapTivate™ technology](#)
 - [Automating Capacitive Touch Sensor PCB Design Using OpenSCAD Scripts](#)
 - [Capacitive Touch Gesture Software and Tuning](#)
 - [Capacitive Touch Hardware Design Guide](#)
 - [Capacitive Touch Through Metal Using MSP430™ MCUs With CapTivate™ Technology](#)
 - [Sensitivity, SNR, and design margin in capacitive touch applications](#)
- TI designs:
 - [64 Button Capacitive Touch Panel With CapTivate Technology Design Guide](#)
 - [Access Control Panel With BLE, Cap Touch, and Software Integration Ref Design](#)
 - [Capacitive Touch Thermostat User Interface Design Guide](#)
 - [Capacitive-Based Liquid Level Sensing Sensor Reference Design](#)
 - [CapTivate™ E-Lock Design Guide](#)

- [Gesture-Based Capacitive Touch Speaker Interface Reference Design](#)
- [Liquid Tolerant Capacitive Touch Keypad Reference Design](#)
- [MSP432 With MSP430 Microcontroller With CapTIvate Technology, Haptics, and LCD](#)
- [Noise Tolerant Capacitive Touch Human Machine Interfaces Design Guide](#)
- [Touch Remote Control Reference Design With CapTIvate Technology](#)
- [Low Power Touch Through Glass Design Guide](#)
- [Touch Through Glass With Sharp® LCD Design Guide](#)

5.2.1.2 Ultrasonic sensing

This technology is designed for high-precision liquid and gas flow measurement applications. It is mainly used in water and gas meters.

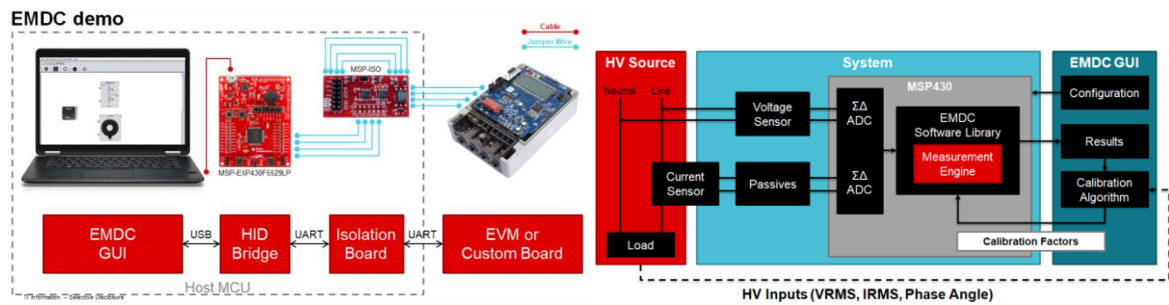


Picture 5-5 Ultrasonic sensing diagram

- Product page: [Ultra-low-power SoCs for water, gas and heat meters](#)
- GUI product page: [MSP430 MCUs Ultrasonic Sensing Design Center](#)
- Video series:
 - [Ultrasonic sensing for water flow meters](#)
 - [Ultrasonic sensing for gas flow meters](#)
- EVM boards★:
 - [EVM430-FR6047](#) (For water flow metering sensing)
 - [EVM430-FR6043](#) (For water and gas metering sensing)
- Application notes:
 - [Frequently asked questions \(FAQ\) on ultrasonic sensing technology](#)
 - [How to Synchronize the MSP430FR6047 Clock System Domains With the USS Oscillator](#)
 - [Waveform capture based ultrasonic sensing water flow metering technology](#)
 - [Ultrasonic sensing of gas flow](#)
 - [MSP430FR6043-based ultrasonic gas flowmeter quick start guide](#)
 - [MSP430FR6047-based ultrasonic water flow meter quick start guide](#)
 - [Ultrasonic sensing solution submodules overview](#)

5.2.1.3 Energy Measurement

This technology can do high precision current, voltage, active and reactive power detection, etc. It is mainly used in electric meters, supporting CT, Rogowski coil and shunt current sensors.



Picture 5-6 Energy Measurement diagram

- GUI product page: [Energy Measurement Design Center for MSP430 MCUs](#)
- User's guide★: [Energy Measurement Technology Guide](#)
- Video series: [Energy Measurement Design Center for MSP430 MCUs: Training Series](#)
- EVM boards (For GUI for these three EVMs, please refer to [EMDC](#)):
 - [EVM430-i2040S](#)(Single-phase or sub-metering energy measurement)
 - [EVM430-F6736](#)(Single-phase Meter : Class 0.2 Accuracy)
 - [EVM430-F6779](#)(Three-phase Meter : Class 0.2 Accuracy)
- Application notes:
 - [Implementation of a One- or Two-Phase Electronic Watt-Hour Meter Using the MSP430i20xx](#)
- TI designs:
 - [ULP Temperature Compensated RTC on MSP430F6736 Design Guide](#)
 - [Single-Phase AC and DC Power Monitor with Wire Resistance and EMI Capacitor Compensation](#)
 - [Single-Phase Electric Meter With Isolated Energy Measurement](#)
 - [Three Phase Rogowski Coil Based E-Meter Solution](#)
 - [One-Phase Metrology with Enhanced ESD Protection Reference Design](#)
 - [Class 0.5 Three-Phase Smart Meter Reference Design](#)
 - [Battery Management and Auxiliary Power Supply Options for e-Meters Design Guide](#)
 - [Three-Outlet Smart Power Strip Design Guide](#)
 - [Implementing Wi-Fi Connectivity in a Smart Electric Meter](#)

5.2.1.4 USB integration

MSP430 MCUs include an on-chip USB 2.0 module on several subfamilies. Combined with MSP430 USB Developers Package, the USB development will be simple.

- GUI product page: [MSP430 USB Developers Package](#)
- User's guide★: [Starting a USB Design Using MSP430 MCUs](#)
- Application notes:
 - [Implementing Wi-Fi Connectivity in a Smart Electric Meter](#)
 - [Android Applications With MSP430 USB on Mobile Devices](#)
 - [USB Keyboard Using MSP430 Microcontrollers](#)
 - [USB Field Firmware Updates on MSP430 MCUs](#)

5.2.2 TI reference designs

- [BOOST-IR Infrared \(IR\) BoosterPack™ Plug-in Module User's Guide](#)
- [Level 1 and Level 2 Electric Vehicle Service Equipment \(EVSE\) Design Guide](#)
- [10s battery monitoring, balancing, and comp protection, 50A discharge ref design](#)
- [4-mA to 20-mA Current Loop Transmitter Design Guide](#)

- [10-uA to 100-mA 0.05%-Error High-Side Current Sensing Design Guide](#)
- [Power over Ethernet \(PoE\) reference design for industrial gateways](#)
- [MSP430FR2311 IR Reflection-Sensing Subsystem Design Guide](#)
- [4- to 20-mA Loop-Powered RTD Temperature Transmitter Reference Design](#)
- [Multiparameter Biosignal Monitor Design Guide](#)
- [TIDM-NFC-RW Design Guide](#)
- [Ultra-Low Power Blood Pressure and Heart Rate Monitor Design Guide](#)
- [Highly Integrated, 4½ Digit, Low Power Handheld DMM Platform Reference Design](#)
- [MSP430 Software RGB LED Control Design Guide](#)
- [ADAS Multi-Sensor Hub Design With Quad 4-Gbps FPD-Link III, Dual CSI-2 Output](#)
- [0-A to 1-A Single-Supply Low-Side Current-Sensing Solution Design Guide](#)
- [Air Quality Sensor Design Guide](#)
- [SMBus Design Using MSP430 Design Guide](#)
- [EEPROM Emulation and Sensing With MSP FRAM Microcontrollers Reference Design](#)
- [Inductive Proximity Sensing Design Guide](#)
- [Wi-Fi Enabled Level 1 Level 2 Electric Vehicle Service Equipment Design Guide](#)
- [TEC driver reference design for 3.3-V inputs](#)
- [Case Tamper Detection Reference Design Using Inductive Sensing](#)
- [ADAS 8-Channel Sensor Fusion Hub Ref Design With Two 4-Gbps Quad Deserializer](#)
- [Smart Solenoid Driver With Predictive Maintenance Reference Design](#)
- [ESI + LDC Inductive Linear Position Sensing Design Guide](#)
- [Voice Band Audio Playback Using a PWM DAC Design Guide](#)
- [Memory Emulation Using 1-Wire Communication Protocol Design Guide](#)
- [+/-1A Single-Supply Low-Side Current Sensing Solution Design Guide](#)
- [IO-Link Firmware Update Reference Design Leveraging MSP430™ FRAM Technology](#)
- [Output Current Sensing and Limit, Plug-in Detection in Power Bank Design Guide](#)
- [NFC Authentication for an EV Charging Station \(Pile\) Reference Design](#)
- [KNX Thermostat TI Design Guide](#)
- [Temperature Transmitter on Single Chip Mixed-Signal MCU](#)
- [Data Collector for wM-Bus T-/C-Modes and DSSS-Coded Long-Range Mode Design Guide](#)
- [Thermostat Implementation With MSP430FR4xx Design Guide](#)
- [Remote Controller of Air Conditioner Using MSP430 Design Guide](#)
- [Filtering and Signal Processing Ref Design Using MSP430 FRAM Microcontroller](#)
- [MSP430 Low Power Orientation Tracker Design Guide](#)
- [Data Isolation for Loop-Powered Applications Design Guide](#)
- [MSP-EXP430FR6989 & FRAM to Enable Compute Thru Power Loss Utility Design Guide](#)
- [QVGA 3D Graphics on MSP430 Microcontrollers Design Guide](#)
- [18-V/400-W 98% Efficient Compact Brushless DC Motor Drive Design Guide](#)
- [12V to 24V, 27A Brushed DC Motor Reference Design](#)
- [Reference Design for Wireless Condition Monitor for Motors and Pumps](#)
- [24V/36W BLDC Motor Driver Reference Design With Close-Loop Speed Control](#)
- [Driving Three-Phase Stepper Motor With BLDC Motor Driver Reference Design](#)
- [1-PWM Brushless DC Motor Control TI Reference Design](#)
- [Unipolar Stepper Motor Driver Using a Bipolar Stepper Controller Design Guide](#)
- [Wireless Motor Monitor \(WMM\) Design Guide](#)
- [Low-Power Micro Stepper Motor Driver Using FRAM MCU Design Guide](#)

- [Integrated Sensored BLDC Motor Controller Reference Design](#)
- [Dual High Resolution Micro-Stepping Driver](#)
- [10.8-V/250-W, 97% Efficient, Compact BLDC Motor Drive With Stall Current Limit](#)
- [Filtering and Signal Processing Reference Design Using MSP430 FRAM Microcontroller](#)
- [12-V, 15-W Power Limit, Single Driver-Based Stepper, Brushed DC and Actuator Drive Reference Design](#)

5.2.3 **Application notes**

- [Enhance simple analog and digital functions for \\$0.25](#)
- [CRC Implementation with MSP430 MCUs](#)
- [Digital Addressable Lighting Interface \(DALI\) Using MSP430 Value Line](#)
- [EKG-Based Heart-Rate Monitor Implementation Using the MSP430G2xx LaunchPad Kit](#)
- [Implementing a Direct Thermocouple Interface With the MSP430F4xx and ADS1240](#)
- [Implementing a Single-Chip Thermocouple Interface with the MSP430F42xA MCUs](#)
- [Implementing An Ultra-Low-Power Keypad Interface With MSP430 MCUs](#)
- [Implementing An Ultra-Low-Power Thermostat With Slope ADC](#)
- [Implementing IrDA With MSP430 MCUs](#)
- [Infrared Remote Control Implementation With MSP430FR4xx](#)
- [Fuzzy Logic Motor Control With MSP430 MCUs](#)
- [Servo Motor Controller Using MSP430™ MCUs](#)
- [Stepper Motor Control Using MSP430™ MCUs](#)
- [1.8V – 5.5V Input, High-Efficiency DCD Converter Reference Design for MSP430](#)
- [1-Wire Enumeration](#)
- [7-Segment LED Stopwatch Using Low-Memory MSP430™ MCUs](#)
- [A Simple Glass-Breakage Detector Using an MSP430 MCU](#)
- [A Single-Chip Pulsoximeter Design Using the MSP430](#)
- [Calling Convention and ABI Changes in MSP GCC](#)
- [Dual-Ray Smoke Detector Design With MSP430FR2355 MCUs](#)
- [Getting Started With EEMBC ULP Bench on MSP-EXP430FR5969](#)
- [Heart-Rate and EKG Monitor Using the MSP430FG439](#)
- [Hysteresis Comparator With UART Using Low-Memory MSP430™ FRAM MCUs](#)
- [Interfacing an MSP430 MCU and a TMP100 Temperature Sensor](#)
- [Interfacing MSP430™ MCUs With MMC or SD Flash Memory Cards](#)
- [Interfacing the 3-V MSP430 MCU to 5-V Circuits](#)
- [LC Sensor Rotation Detection With MSP430 Extended Scan Interface \(ESI\)](#)
- [Li-Ion Battery Charger Solution Using an MSP430™ MCU](#)
- [Low -Power Hex Keypad Using MSP430™ MCUs](#)
- [Method to Select the Value of LC Sensor for MSP430 Extended Scan Interface \(ESI\)](#)
- [MSP430 Advanced Power Optimizations: ULP Advisor SW and EnergyTrace Technology](#)
- [MSP430 Based Lithium-Ion Polymer Battery Charging and Gauging Solution Using USB](#)
- [MSP430 Embedded Application Binary Interface](#)
- [MSP430's Analog Combo Enables True Single-Chip Pulse Oximeter Designs](#)
- [MSP430F42xA Single-Chip Weight Scale](#)
- [Multi-Cell Li-Ion Battery Management System Using MSP430F5529 and bq76PL536](#)
- [Multi-Function Reset Controller With Low-Memory MSP430™ MCUs](#)
- [Nine-Axis Sensor Fusion Using Direction Cosine Matrix Algorithm on MSP430F5xx](#)

- [Powering the MSP430 from a High Voltage Input using the TPS62122](#)
- [Programmable Clock Source Using MSP430™ MCUs](#)
- [Programmable Frequency Locked Loop Using MSP430™ MCUs](#)
- [Programmable System Wake-up Controller Using MSP430™ MCUs](#)
- [Quadrature Encoder Position Counter With MSP430™ MCUs](#)
- [Random Number Generation Using MSP430FR59xx and MSP430FR69xx Microcontrollers](#)
- [Random Number Generation Using MSP430™ MCUs](#)
- [Revised Pulse Oximeter Design Using the MSP430](#)
- [Simple Power Sequencer Using MSP430™ MCUs](#)
- [Single-Slope Analog-to-Digital Conversion Technique Using MSP430™ MCUs](#)
- [Single-Wire Communication Host With MSP430™ MCUs](#)
- [Tamper Detection Using Low-Memory MSP430™ MCUs](#)
- [Using MSP on KNX Systems Application note](#)
- [Using power solutions to extend battery life in MSP430\(TM\) MCU applications](#)
- [Using the MSP430FR6047 Wireless M-Bus Serial Library for Metering Applications](#)
- [VLO Calibration on the MSP430FR4xx and MSP430FR2xx Family](#)
- [Voltage Monitor With a Timestamp Using a Low-Memory MSP430™ MCU](#)
- [Wave Digital Filtering Using an MSP430 MCU](#)
- [Wide-Vin Battery-Charger Using SMBus MSP430 MCUs and bq Fuel Gauges](#)

5.3 Encryption and security

Implementations of the AES, DES, TDES, and SHA-2: Used for devices without hardware acceleration for these algorithms.

- User's guide: [C Implementation of Cryptographic Algorithms](#)
- Algorithms:
 - [Advanced Encryption Standard](#)
 - [Data Encryption Standard](#)
 - [Secure Hash Standard](#)

Secure firmware updates: Some applications are in need of secure firmware updates. The following has been made available for these situations.

- Application notes: [Secure In-Field Firmware Updates for MSP MCUs](#)
- Crypto-Bootloader:
 - User's guide: [Crypto-Bootloader \(CryptoBSL\) for MSP430FR59xx and MSP430FR69xx MCUs User Guide](#)
 - Application notes: [Crypto-Bootloader - Secure In-Field Firmware Updates for Ultra-Low Power MCUs](#)
 - Firmware: [Crypto Bootloader](#)

IEC 60730 Safety Applications:

- User's guide: [Safety Manual for MSP430G2xx, F5xx, and FR57xx in IEC 60730 Safety Applications](#)

5.4 TI quality introduction

5.4.1 TI quality policy

Quality is foundational to achieving TI business objectives. TI is committed to satisfying applicable requirements and providing quality products to customers around the world by:

- Encouraging and expecting the creative involvement of every Tier

- Listening to our customers
- Continuously improving and innovating our products, processes and services

5.4.2 [TI product reliability](#)

TI is committed to delivering high quality and reliable semiconductor solutions that meet customers' needs. On Reliability page can easily find quality and reliability related information and data, like:

- [Qualification summary](#) ★: Used to search reliability data of related devices. Representative data summary of the material sets, processes, and manufacturing sites used by the device family.
- **Reliability testing:** Listed the various types of testing that TI conducts for reliability of its products.
- **DPPM/FIT/MTBF estimator:** The DPPM/FIT/MTBF estimator search tool allows you to find generic data based on technology groupings to estimate these typical questions and shows conditions under which the rates were derived.
- **Ongoing reliability monitoring:** The search tool of ongoing reliability monitor (ORM) program will provide the quarterly ORM report by wafer fab process or device package family.

5.4.3 [TI packaging introduction](#)

MSP430 can provide various packages to support customers' application needs. On TI.com, select **Quality & reliability** -> **Additional information** -> **Packaging information** path to easily find proper package considering package size, reliability and performance expectation. This resource also provided SMTA recommendations on a variety of packaging topics. Besides, the [Ultra Librarian software](#) tool can aid on layout design on specific package.

5.4.4 **Customer returns**

Customer satisfaction is important to TI, and customer returns are handled with care and urgency. To ensure timely resolution of customer concerns, TI has an established customer return process for customers who wish to return parts. On [Customer returns page](#) can easily find detail guideline when returning material to TI.

Before planned to return parts, below are some general debugging documents to support isolating the possible problem with solution in a time manner.

Table 5-1 MSP430 quality related resources

Item	Document
Errata	Errata check per MCU revision: if MCU fail signature stated in device errata per revision
Troubleshooting guide	Troubleshooting Guidelines for MSP Devices (TI web)
IC ESD	Electrostatic Discharge(ESD) (TI web)
System ESD	MSP430™ System-Level ESD Troubleshooting Guide (TI web)
Programming	MSP430™ Programming With the JTAG Interface (TI web)
EOS introduction	Understanding Electrical Overstress - EOS (Whitepaper 4) (Industry Council web)
Others	ESD Diode Current Specification (TI web) MSP430™ System-Level ESD Considerations (TI web)