

# xCORE™ : Architecture Overview



## xCORE FEATURES

- Multiple 32bit processor cores
- Software defined interfaces
- Low latency
- Much faster I/O response
- Completely timing deterministic
- DSP and security processing supported
- Easy to use
- Makes designing complex embedded system simple

## xCORE MULTICORE MICROCONTROLLER

xCORE is a new class of microcontroller that has multiple processor cores, incredibly flexible I/O, and a unique timing deterministic architecture that makes it very easy to use. Using xCORE, you can easily design new embedded electronic systems which exactly meet your end-customer's needs and which deliver exact timing.

Unlike conventional microcontrollers, the xCORE multicore microcontroller is able to run multiple real-time tasks *simultaneously*. xCORE multicore microcontrollers support high-level programming languages with 32bit processor cores and execute the program using RISC instructions. Each logical processor core can execute tasks running computational code, advanced DSP code, control software (including taking logic decisions and executing a state machine) or software that handles I/O operations.

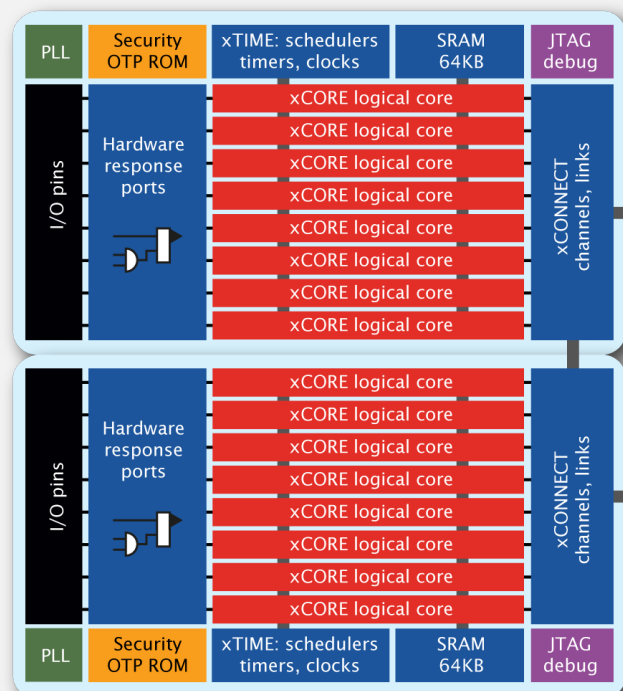
## Flexible: Software defined peripherals

With xCORE you can program in the exact interfaces you need to meet your requirements. For example you can add USB. You can program your xCORE to support USB 2.0 Audio class 2 in either synchronous or asynchronous modes – and if you want multichannel, well program what you need. You need Ethernet? – you can download the Ethernet xSOFTip block using our development tools. But you can also have 1588 time-stamped Ethernet, or support the new Ethernet Audio Video Broadcast (AVB) standard or real-time EtherCAT. You can add UARTs, I2C or SPI ports - as many as you want. Audio I2S – how many channels do you need? Pulse width modulators can be programmed to your exact requirements.

In fact we currently support over 40 different xSOFTip peripheral blocks that can be programmed in any combination to match your exact requirements and the family of xSOFTip blocks continues to grow. If you don't see what you want in our library, there is a developer community that may have an example of what you need. Alternatively you can always program your own unique interface.

### xCORE Architecture

The xCORE multicore microcontroller is made up from multiple 'logical processor cores' distributed across Tiles. Devices are currently available with 4, 6, 8, 10, 12, 16 and 32 logical cores on 1, 2 and 4 tiles. The xCORE Tile provides 500MIPS of compute (on a 500MHz device) making it much more powerful than conventional microcontroller products. The logical processor cores share processing resources and memory on the Tile, but each has separate register files. Each logical processor core gets a guaranteed slice of processing power (up to 125 MIPS on a 500MHz device), which is controlled by the unique xTIME timing and synchronization technology. The time-slicing is executed in such a way that it is completely transparent – the logical processor cores appear as separate, parallel processors, capable of running multiple real-time tasks simultaneously. In fact it is the xTIME technology that gives xCORE its unique timing predictability and real-time responsiveness.



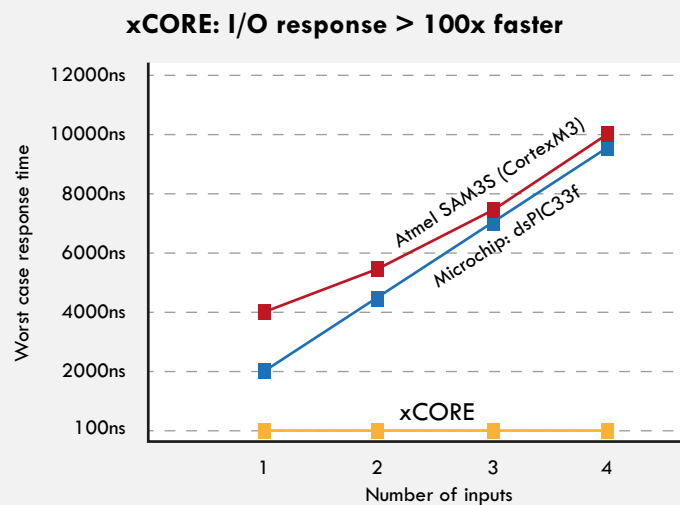
## DSP and Security:

The xCORE processor provides a comprehensive range of native DSP operators and instructions that allow you to integrate high speed digital signal processing into your design for audio signal processing, for industrial control signal transformation and control plus for video processing.

The security block in xCORE working together with logical processor cores also allows you to configure and implement security algorithms to ensure that your code is secure and your intellectual property protected. You can safely encrypt your code in external flash. Of course, you can also add security keys into your critical designs and perform protected mode processing.

## Easy to use

Our aim is to make the xCORE processor incredibly easy to use. The xSOFTip and xTIMEcomposer software development suite are available on-line and free to download. We provide training material and in-tool tutorials that you can use to learn more about the architecture and to try out different examples. Our development boards allow you to test your designs in hardware and provide plug in modules where you can try different interfaces or create custom connections. We are continuously working to improving our design tools and the user experience and we are keen to hear your feedback and input.



## Timing Deterministic

The multiple 32bit processor cores in xCORE are easy to use and simple to program using standard high level languages such as C or C++. We have a uniquely scalable, timing deterministic architecture that provides extremely low latency and an I/O response that is 100 times faster than standard processors. Our xTIMEcomposer software development kit lets you set and maintain critical timing requirements. When your design is finished you can test it dynamically, using our full timing simulator, or use our static timing analyzer for detailed analysis. We don't know of any other processor that lets you do that – because no other processor provides the predictable timing performance and response that xCORE supports. While other processors take 10s of milliseconds, xCORE measures timing at 10ns resolution.

## How does xCORE work...

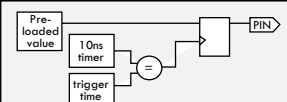
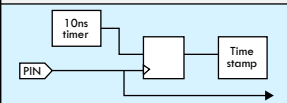
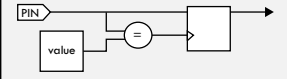
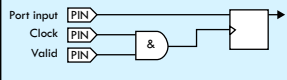
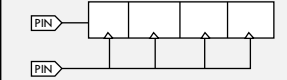
xCORE is a code efficient 32bit RISC processor that is made up from tiles, with each tile having multiple logical processor xCores. In the XS1 family of devices each xCORE Tile contains up to 8 logical cores and we have XS1 devices available that have 1, 2 or 4 tiles delivering 4, 6, 8, 10, 12, 16 and 32 processor cores respectively.

To further enhance performance the xCORE instruction set includes support for long arithmetic; including MAC operators, CRC and other DSP operators. In addition security and cryptography functions are provided allowing security applications to be supported as well as ensuring that code can be kept secure and IPR protected.

Each xCORE Tile has a single unified memory system, which is shared for program and data by all of the cores in that tile. Multiple cores can share the same program in memory and can pass ownership of data between them. The xCORE processor does not use and does not need caches, making program execution completely timing deterministic. If a core is waiting for data, the xTIME hardware scheduler will pass the execution resource to the next core making efficient use of the available processor resource and saving power.

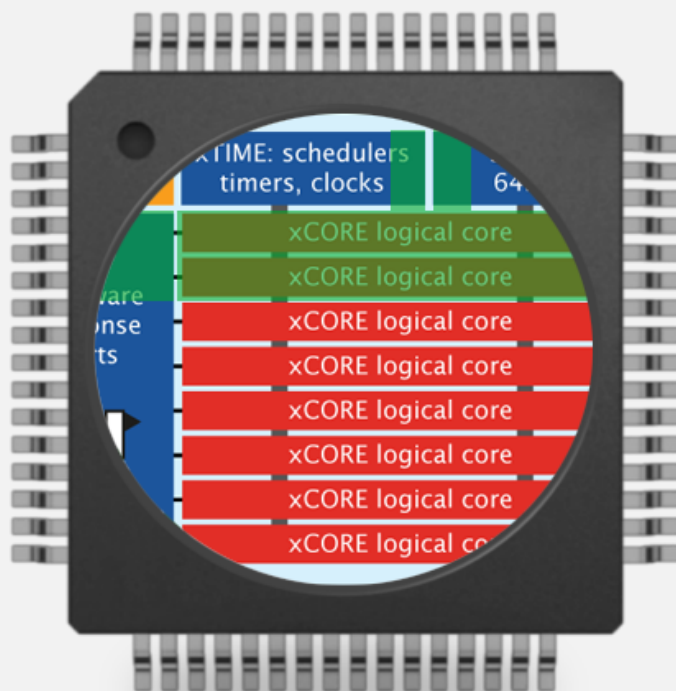
### I/O Ports and Port Logic

The programmable I/O Ports on xCORE processors make the devices incredibly flexible and are a unique feature. The architecture has a tightly integrated set of I/O ports controlled directly from the logical cores. Data is transferred directly between the logical processor core register files and the I/O ports, avoiding the use of memory and eliminating latency. The ports can serialize and deserialize data enabling the processor to handle high-speed data streams. They can also timestamp data arrival, and accurately control the time at which data is transferred to or from the pins. This level of high performance control allows complex I/O peripherals to be implemented and built using software. XMOS provides a complete range of software based peripheral functions called xSOFTip which includes popular functions such as USB 2.0, Ethernet, CANBus, high speed Pulse Width Modulators, as well as timing deterministic I/O such as Ethernet AVB.

	Timed Input / Output	<ul style="list-style-type: none"><li>- Generate arbitrary timed output waveforms under software control</li><li>- Sample signals at specific times</li><li>- 10ns resolution</li></ul>
	Time-stamping	<ul style="list-style-type: none"><li>- Reads the current time in the port</li><li>- Provides an origin for timed I/O</li><li>- 10ns timer</li></ul>
	Predicated Input	<ul style="list-style-type: none"><li>- Core waits for given pin state</li><li>- Responsive software state machines</li></ul>
	Clocked port with strobe	<ul style="list-style-type: none"><li>- Synchronise to external clock domains</li><li>- Support for throttled data</li></ul>
	Dedicated serialization hardware	<ul style="list-style-type: none"><li>- 32bit serialize/deserialize data</li><li>- Extends pin data rate beyond instruction rate - 60Mbps</li></ul>

## xSOFTip

xSOFTip software defined peripherals are built using a combination of I/O Ports, xCore logical processors and SRAM, with most xSOFTip blocks fitting in just one xCore logical processor.



## Creating your design...

The xTIMEcomposer development tools provide a familiar embedded software development environment built on industry-standard platforms. You can program xCORE processors using high level languages such as ANSI C and C++, or assembly if required – in any combination that suits your needs. To make xCORE even easier to use, XMOS has created some language extensions to C that support parallel task and timing control – we call them XC. If you are familiar with C you will find the XC language extensions easy to use. You can also create a high level script that defines and connects parallel processor tasks, DSP with I/O peripherals in your design and which controls the real-time events in your design.

Functional problems can be identified and fixed using the XMOS GNU Debugger (GDB) whilst our unique XTA static timing analyzer can be used to validate that all real-time requirements are met without the need for complex and time-consuming dynamic test suites.

Want to know exactly what's happening inside the processor and analyze the behavior of the system? Then use the XScope system to collect data from a running application in real-time.

When you want to target real hardware, our board utilities provide all you need for both your development and manufacturing environment. During development, you might want to load programs from a host PC over JTAG. In a manufactured design, you need to be able to program your image securely into FLASH. XMOS tools and the security module allow you to encrypt programs on flash and enable a secure bootloader to ensure both program and device authenticity. Need in-field upgrades? XMOS tools allow multiple firmware releases to be managed over the product life cycle.

## What can xCORE do...

The xCORE flexible multicore microcontroller is the ideal solution for a wide range of low latency, real-time communications and real-time control applications.

### Consumer and audio:

xCORE is the industry standard solution for high-end digital audio. Our products support the demanding USB Audio Class 1 and Audio Class 2 standards plus all other audio interfaces including S/PDIF and I2S. We don't just support these interfaces – we have designed our audio xSOFTip blocks to ensure you get the highest musical signal integrity and lowest latency which is why xCORE is the solution for all leading high-end audiophile and professional audio equipment.

In addition to USB, xCORE is also the leading solution for Ethernet Audio Video Broadcast (Ethernet AVB). This new Ethernet standard is being adopted in professional audio and is now moving to consumer audio too and xCORE can be found today in a range of multichannel Ethernet AVB equipment and is being adopted as the only viable solution for low cost Ethernet AVB in musical instruments and microphones.

You don't just find xCORE in high end equipment, with its low cost and high levels of integration, xCORE devices are used in iPod docks, soundbars, surround sound systems and other high volume consumer audio applications as well as in audiophile systems, multichannel audio equipment, DJ decks and the complete range of pro-audio products. xCORE is the leading solution for all digital audio.



*Pro-Audio*



*Industrial*



*Consumer-Audio*



*Consumer*



*Automotive*



## Industrial:

With precise real-time support, low latency and a wide range of flexible interfaces available, xCORE can be found in a diverse range of industrial applications. These applications range from industrial communications, including serial to Ethernet bridging, real-time 1588 time-stamped Ethernet as well as other industrial Ethernet standards. With highly flexible Pulse Width Modulator (PWM) xSOFTip blocks and DSP processing capability, xCORE is used for high-end motor control and is also in renewable energy and power train applications supporting precise power inversion control. The true parallel multi-tasking capability of xCORE makes it ideal for complex motion control and xCORE can be found in range of robotic systems. Many un-manned vehicles rely on xCORE for their fast response and control. With real-time response that is up to 100 times faster than other microcontrollers, xCORE is emerging as a performance leading solution for many demanding industrial control applications.

## Displays; imaging and human machine interfaces:

With its low latency and fast real-time support, xCORE is ideal for frame buffer control and is also used for a range of fast imaging applications. xSOFTip software blocks are available for LCD display control and are available to support a range of image processing tasks such as motion JPEG decompression. Multi-touch can be supported, and with support for fast image processing and motion detection plus the ability to support voice recognition xCORE is emerging as the ideal solution for the next generation of advanced Human Machine Interfacing (HMI) applications that require a combination of touch, voice and human gestures.



## Automotive

xCORE is today the standard for Ethernet AVB end-points and as Ethernet AVB becomes adopted as a standard in the next generation of infotainment systems for cars, xCORE is finding a wide range of applications. With xSOFTip support for a wide range of existing automotive standards including CANbus and MOSTbus, plus its precise deterministic real-time support and importantly a secure compute environment, xCORE is emerging as a strong solution for a range of automotive applications. XMOS is committed to supporting a range of automotive qualified xCORE products.

## Summing up:

The xCORE family of flexible multicore microcontrollers allow you to program the exact interfaces and functionality you need for your design and they provide a level of real-time performance not seen in other processors.

To make designing your system easy, XMOS provides a large and growing selection of xSOFTip - soft peripheral IP and function blocks as well as software libraries and drivers that you can use to program your xCORE processor so that it matches your exact requirements.

To make this design process easy xTIMEcomposer - a full suite of compilers and debuggers - helps you build your design in a familiar software development environment, whilst unique static timing analysis and simulation tools mean that you can test your design to a level not possible on other processors. Meeting critical timing is easy and making your design robust and secure is part of the design process.

With a range of flexible development boards, you can quickly create your embedded system design using xCORE.

When your design needs higher performance, lower latency, more precise real-time control, or a specific set of interfaces then xCORE is the answer. In fact when your designs must be absolutely, positively right, you need XMOS.



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