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32 Bits for a Buck

Luminary Micro's ARM-Based MCUs Cost As Little As a Dollar

By J. Scott Gardner {6/5/06-02}

The history of microprocessors is littered with the wreckage of countless startups that entered the market with brand-new proprietary architectures. In most cases, these new architectures offer brilliant new features, with technical advantages over established architectures.

Alas, most new startups learn the same cruel lesson as the marketplace crushes new technology in favor of proven architectures with an established support ecosystem. However, this article is about a startup with a veteran management team that is heeding the lesson to create a different kind of microprocessor company.

32 Bits Don't Cost an ARM and a Leg

Luminary Micro is a fabless semiconductor vendor of general-purpose microcontrollers, but the company is using a 32-bit CPU core that is openly available to competitors. Luminary Micro's initial business strategy exploits the market advantage gained by its lead-partner role with ARM for the Cortex-M3 core—a compact core designed specifically for low-cost, low-power MCUs. (See *MPR 11/29/04-01*, "ARM Debuts Logical V7.")

To accelerate the adoption of its new Stellaris family of ARM-based MCUs, Luminary Micro rocked the industry on March 26 by pricing its first chips at $1 (the 10,000-unit distributor price). That's two-thirds the price of ARM-based MCUs from Philips, the previous low-price leader. (Figure 1 is a photo of the 32-bits-for-a-buck LM3S101.) Luminary Micro's price-leader strategy further reduces the perception that 32-bit CPUs belong only in high-end systems. System designers with 8- and 16-bit devices now have fewer reasons not to ascend into the 32-bit universe.

However, Luminary Micro made its debut with only two devices. A key part of the company's business strategy is to rapidly proliferate derivative products to create a broad portfolio of MCUs for an expanding range of applications. On May 22, Luminary Micro announced four new members of the Stellaris family to accommodate customers needing more onboard memory and general-purpose I/O (GPIO) ports.

With more I/O, the new LM3S301, LM3S310, LM3S318, and LM3S316 necessarily have more pins: 48, compared with 28 pins on the original LM3S101 and LM3S102. They also cost a little more, starting at $2.53. But in addition to allowing

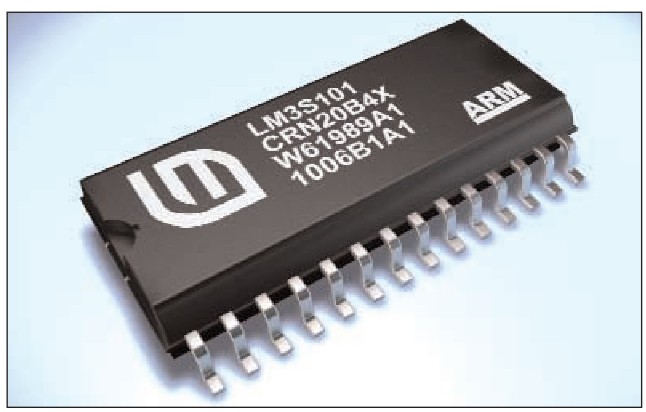

Figure 1. Distributors are selling this 32-bit ARM-based microcontroller for only $1 in 10,000-unit volumes. Before May 22, the 28-pin LM3S101 was half of Luminary Micro's product line. With the newly announced LM3S3xx series, the company is now shipping six 32-bit MCUs with the ARM Cortex-M3 processor core. (Photo: Luminary Micro)

more I/O, some of the new pins support a new, integrated analog-to-digital converter (ADC).

Table 1 highlights the key features of the new Stellaris devices and shows some competing 8-bit devices. Luminary Micro believes that its primary competitors are not other ARM-based vendors. Instead, the company wants to lure customers away from traditional 8-bit MCU architectures. The rapid introduction of new MCUs indicates that Luminary Micro is executing well and is a company to watch.

Building From the Core to the Cortex

Although ARM and Luminary Micro are separate companies, their MCU strategies are linked at the spinal cord. Both companies share the vision that the Cortex-M3 will displace traditional MCU architectures. The Cortex-M3 is based on the ARMv7M instruction-set architecture (ISA). It stirred some controversy at its introduction because it exclusively supports the Thumb-2 instruction set, not the entire 32-bit ARM instruction set. The Cortex-M3 is optimized for power efficiency, small die size, low interrupt latency, and deterministic operation.

Thumb-2 adds 130 instructions to Thumb, the original subset of 16-bit instructions that allows ARM processors to dramatically reduce code size. Processors supporting Thumb are dual-mode CPUs that frequently switch back and forth between 32-bit ARM instructions and 16-bit Thumb instructions. Their requirement to enter 32-bit ARM mode during exception processing is a particularly onerous limitation. In contrast, Thumb-2 is a single instruction set with 32- and 16-bit instructions that doesn't require mode switching. However, previous ARM binaries won't run on Thumb-2 machines like the Cortex-M3, even though the original Thumb instructions are compatible with Thumb-2. Programmers can port ARM assembly-language code by using ARM's Unified Assembler libraries, but C libraries require recompilation.

Like the ten-year-old ARM7TDMI—a staple of other low-cost ARM-based MCUs—the Cortex-M3 has no instruction or data caches. Cache behavior can be indeterminate, which is a handicap in real-time control applications. Yet despite having new features, the Cortex-M3 is smaller than the ARM7TDMI. The processor core requires only 33,000 gates, which rises to a still-economical 60,000 gates after adding a memory-protection unit (MPU), bus interface, and other tightly coupled components. Figure 2 shows a block diagram of the Cortex-M3.

Turning a RISC CPU Into an MCU

Several attributes of MCUs make them different from other embedded processors. To highlight the distinction, consider the common application for motor control. In a simple system, there is a feedback path that signals the MCU to indicate the position of the motor (or the device being moved). The MCU must quickly respond to this position information by changing the motor voltage (or the pulse rate, if the motor is a stepper type).

For example, a robot hand may pick up an egg by closing mechanical fingers until the sensors indicate contact with the egg's surface. The MCU must process the data from the sensors and quickly stop the motor that is closing the robot hand. If the processor can't respond in a deterministic fashion—possibly because of cache misses or page faults—then the robot may occasionally make an omelet. This is why the Cortex-M3 fetches instructions and data directly from on-chip flash memory or SRAM instead of caches.

The control system also must guarantee that the processor handles exceptions as quickly as possible, because the CPU may be processing other tasks when it receives an external interrupt warning of imminent egg breakage. The Cortex-M3 reduces interrupt latency by implementing hardware to save

Feature	LM LM3S301	LM LM3S310	LM LM3S315	LM LM3S316	Microchip PIC18F1320	Microchip PIC18F4431	Freescale MC908GR16CFAE
CPU Core	ARM Cortex-M3	ARM Cortex-M3	ARM Cortex-M3	ARM Cortex-M3	PIC18	PIC18	CPU08
Core Freq	20MHz	25MHz	25MHz	25MHz	40MHz	40MHz	8MHz
Flash Memory	16K	16K	16K	16K	8K	16K	16K
SRAM	2K	4K	4K	4K	256K	768K	1K
GPIO (min/max)	12/33	3/36	7/32	3/32	n/a	n/a	n/a
RT Clock	Yes	Yes	Yes	Yes	—	—	—
Timers	2 x 32b, 4 x 16b	2 x 32b, 4 x 16b	2 x 32b, 4 x 16b	3 x 32b, 6 x 16b	3 x 32b, 6 x 16b	3 x 32b, 6 x 16b	3 x 16b, 1 x 8b
I²C Interface	—	—	—	1	—	1	—
SSI	1	1	1	1	1	1	—
UART	1	2	2	2	1	1	1
ADC	3 channels 250K samples	—	2 channels 250K samples	4 channels 250K samples	7 channels 30K samples	9 channels 200K samples	8 channels 60K samples
Analog Comparators	2	1	2	3	1	1	—
Dedicated PWM	—	—	2	6	2	4	1
Capture/Compare/PWM	1	2	2	6	6	6	1
Int Temp Sensor	—	—	Yes	—	Yes	Yes	—
Package	LQFP-48	LQFP-48	LQFP-48	LQFP-48	QFN-28	TQFP-44	LQFP-48
Availability	Samples now Prod. 3Q06	Samples now Prod. 3Q06	Samples now Prod. 3Q06	Now	Now	Now	Now
Price (10K units)	$2.53	$3.84	$4.37	$4.62	$2.49	$4.68	$4.00

Table 1. Luminary Micro designed the latest Stellaris microcontrollers to match up against 8-bit MCUs from Microchip and Freescale. More memory, more pins, and the integration of a multichannel ADC lead to higher pricing for this category of MCUs.

the CPU state during an exception. Only 12 cycles after receiving an external interrupt, the processor can pass control to the interrupt handler.

In addition, the Cortex-M3 has a nested interrupt controller that can avoid unnecessary stack operations. For instance, if the processor receives a higher-priority interrupt while handling a previous interrupt, there's no need to pop state information off the stack before returning from the first interrupt. The Cortex-M3 knows it will transfer program control to the next interrupt handler, which would require pushing the same state information back on the stack. This "tail chaining" operation reduces memory traffic and speeds up interrupt processing, reducing latency to six cycles.

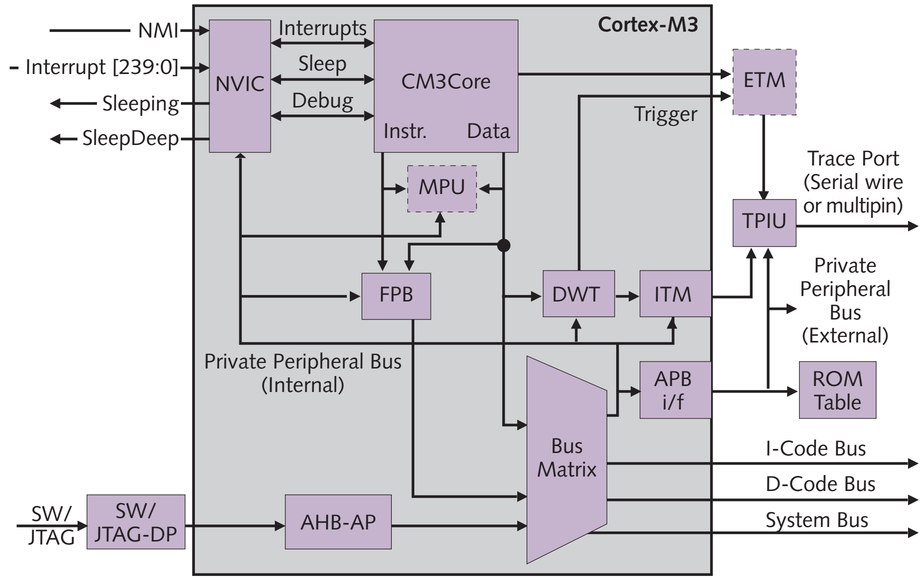

Figure 2. ARM's Cortex-M3 processor uses a cacheless design to improve deterministic performance with control-oriented applications. The memory-protection unit (MPU) and embedded trace macrocell (ETM) are optional components.

How to Build a 32-bit MCU for $1

Luminary Micro wanted to make a bold statement by aggressively pricing its first ARM-based MCUs at $1, because a startup company needs to grab the attention of the marketplace. The company hasn't disclosed the die sizes of these devices, but TSMC fabricates them in a well-worn 0.25-micron CMOS process. This process (TSMC CE025) uses five layers of metal and two layers of polysilicon, and it can implement mixed-signal components and embedded flash memory.

With its relatively large feature size of 0.25 micron, TSMC's process still has good gate density while suffering less transistor leakage than smaller processes. The Cortex-M3's simple three-stage pipeline and cacheless design limit the clock rate (20MHz for Luminary Micro's first devices). ARM notes that the Cortex-M3 can reach speeds of 120MHz in TSMC's 0.18-micron G process. However, a lower clock rate reduces power consumption and package cost. An inexpensive wire-bonded, plastic, small-outline integrated circuit (SOIC) package is adequate for these chips. With only 8KB of flash and 2KB of SRAM, the LM3S101 and LM3S102 are definitely targeted at low-end applications, but the performance and memory size of these devices are more than adequate for billions of MCU sockets.

Luminary Micro's goal is to rapidly build a broad product line of MCUs, which drives the company's make-or-buy decisions. For the first Stellaris parts, Luminary Micro has licensed intellectual property (IP) for all the peripherals and focused on streamlining the design and manufacturing cycle. Going forward, the engineering team will develop new features that differentiate the products without slowing down new introductions.

The four new Stellaris MCUs announced on May 22 use the same Cortex-M3 processor core as the $1 chips,

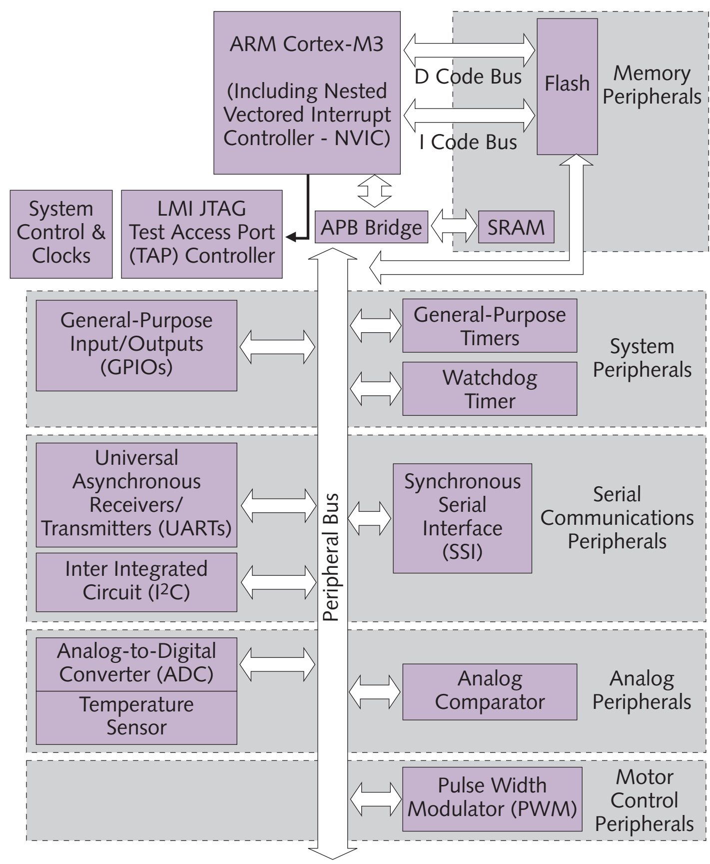

Figure 3. This is a block diagram of the Stellaris LM3S316, but the other MCUs in the Stellaris family share this basic design. The only differences are based on the way pins are configured for specialized peripherals or general-purpose I/O.

but they add an MPU. Note that the Cortex-M3 MPU isn't a sophisticated memory-management unit (MMU) with a translation-lookaside buffer to convert virtual memory addresses to physical addresses. Instead, it uses simple mapping to isolate code, data, and stacks in up to eight physically addressed regions of memory.

As mentioned above, the new chips also have larger 48-pin packages to dedicate more pins for GPIO. As with the LM3S101 and LM3S102, the Stellaris I/O design allows simultaneous access to all integrated peripherals. In contrast, some competing MCUs from other vendors (such as Philips) must resort to multiplexing I/O on some of the pins. Figure 3 is a block diagram of the Stellaris LM3S316.

Table 2 summarizes the features of the entire Stellaris family to date. For all but the LM3S301, the flash and SRAM memories have doubled in size, and the maximum clock rate has increased to 25MHz. The selection of peripherals and I/O across the family makes them suitable for a wider range of applications. Of course, the larger memories, higher clock rates, and larger packages of the new devices also translate into higher manufacturing costs, which is why their prices range from $2.53 to $4.62.

A Smart ADC Expands the Application Domain

Except for customizing the scan chain and debug logic, the engineering team has mostly been working with off-the-shelf logic blocks. Although Luminary Micro licensed the ADC analog block, the engineering team was finally turned loose to invent some new peripheral hardware. The ADC supports up to eight input channels, with an aggregate sample rate of 250,000 samples per second. In addition to sampling external analog sources with the ADC, programmers can dedicate a channel to an on-chip temperature sensor.

To free the CPU from the mundane task of sampling each channel, the logic includes a set of programmable sequencers that control which channels are sampled during a rotating sequence of sample periods. This means that a program can repeatedly sample a single channel (allowing oversampling) or sample multiple channels at different sample rates. The choice is entirely up to the user. The only limitation is that the total number of samples per second cannot exceed 250,000.

Actually, the ADC has four separate sequencers with programmable priorities, and each sequencer can be controlled by multiple trigger sources. By integrating this flexible ADC into the Stellaris devices, Luminary Micro can offer its MCUs for such applications as low-cost medical sensors and industrial controllers. Figure 4 shows a block diagram of the ADC.

Stellaris Versus the Competition

Luminary Micro has set its sights on general-purpose markets served by electronics distributors, meaning that the average customer buys 5,000 to 10,000 units. Those volumes aren't large enough to tempt customers into licensing a 32-bit processor core and designing a specialized ASIC. Aggressive pricing and low clock rates position Stellaris directly against vendors with general-purpose 8- and 16-bit devices, although the LM3Sxx series moves upstream and may run into some fierce competition from low-end 32-bit MCUs.

If one looks first at the competitors with traditional 8-bit and 16-bit cores, it's obvious that Luminary Micro faces a small number of architectures from a large number of vendors. This is particularly the case with the ubiquitous 8051 architecture from companies such as Analog Devices, Atmel, Dallas Semiconductor, Infineon, NEC,

	Luminary Micro					
Feature	**LM3S101**	**LM3S102**	**LM3S301**	**LM3S310**	**LM3S315**	**LM3S316**
ARM Core	Cortex-M3	Cortex-M3	Cortex-M3	Cortex-M3	Cortex-M3	Cortex-M3
Core Freq (Max)	20MHz	20MHz	20MHz	25MHz	25MHz	25MHz
Flash Memory	8K	8K	16K	16K	16K	16K
SRAM	2K	2K	2K	4K	4K	4K
JTAG to Pins	Yes	Yes	Yes	Yes	Yes	Yes
UARTs	1	1	1	2	2	2
GPIO Pins	2–18	0–18	12–33	3–36	7–32	3–32
SSI	Yes	Yes	Yes	Yes	Yes	Yes
I^2C Interface	—	Yes	—	—	—	Yes
Analog Comparators	2	1	2	3	1	1
Int. Temp Sensor	—	—	Yes	—	Yes	Yes
Ext. 32KHz Clock	Yes	Yes	Yes	Yes	Yes	Yes
Watchdog Timer	Yes	Yes	Yes	Yes	Yes	Yes
General-Purpose Timers (1 for RTC)	2	2	2	3	3	3
Brown-Out Reset	Yes	Yes	Yes	Yes	Yes	Yes
LDO Voltage Regulator	Yes	Yes	Yes	Yes	Yes	Yes
ADC Channels	—	—	3 x 10b 250K samples	—	4 x 10b 250K samples	4 x 10b 250K samples
PWM Pins	—	—	2	6	2	4
Capture/Compare/PWM	1	2	2	6	6	6
Operating Temps	Commercial: 0° to 70°C Industrial: -40° to 85°C	Commercial: 0° to 70°C Industrial: -40° to 85°C	Commercial: 0° to 70°C Industrial: -40° to 85°C	Commercial: 0° to 70°C Industrial: -40° to 85°C	Commercial: 0° to 70°C Industrial: -40° to 85°C	Commercial: 0° to 70°C Industrial: -40° to 85°C
Package	SOIC-28	SOIC-28	SOIC-48	SOIC-48	SOIC-48	SOIC-48
Price (10k Units)	$1.00	$1.26	$2.53	$3.84	$4.37	$4.62

Table 2. Luminary Micro now has six MCUs, with more expected later this year. Customers demand the smallest possible chips at the lowest possible price, so MCU vendors must offer a large number of peripheral configurations.

Philips, Renesas, Silicon Labs, ST Microelectronics, Texas Instruments, and even Intel. However, many of these companies use the 8051 in specialized devices and have shifted their focus to new architectures.

With only 14% market share, Freescale held the 8-bit MCU lead in 2005, illustrating just how fragmented the market really is. (See *MPR 5/1/06-01*, "Freely Scaling From 8 Bits to 32.") Other low-end MCU vendors include Microchip with the PICmicro MCUs, National Semiconductor with the COP family, Renesas with the R8 and M16, and NEC with the 78K. There are far too many vendors and products for a thorough comparison, but it is possible to make high-level comparisons of a Cortex-M3 core with any 8- or 16-bit MCU.

Luminary Micro suggests that system designers shouldn't have to justify a need for 32 bits. With price parity, there should be no reason not to use a modern 32-bit architecture in every application. This claim deserves a closer look to analyze some of the trade-offs, because engineers know that nothing is free. Let's look at the potential positives and negatives of using a 32-bit core when an 8-bit device gets the job done.

Code Size: RISC Not So Bloated Anymore

Historically, RISC architectures have suffered from code expansion when compared with CISC machines. As it turns out, modern RISC architectures with 16-bit instruction subsets may have an advantage over older architectures. In fact, ARM claims the Cortex-M3 has four times the code density of the 8051.

There are good reasons for this dramatic difference, especially when modern high-level languages are used. RISC architectures have tuned their instruction sets and register files to efficiently deal with pointers and parameter passing to subroutines. The EEMBC benchmarks report code-size information, but, unfortunately, not enough MCU vendors have publicized their data to allow an overall comparison. In general, it appears that the Cortex-M3 will not require larger code space than other MCUs, and it might even require less. What once was considered a negative for switching to a 32-bit MCU may actually be a positive.

Power efficiency is more difficult to evaluate, especially when relying on data provided by the semiconductor vendors. Every vendor uses different measurement and reporting methods, so it's almost impossible to make direct comparisons. MCU architectures present a great opportunity for marketing games, since "typical" power numbers make assumptions about which of the numerous peripherals are included in the estimate.

Luminary Micro says its first devices are not particularly optimized for low power, although the company has lower-power devices on its roadmap. Moreover, the company has issued an erratum for a bug that causes higher power consumption in sleep and deep-sleep modes. Until the company updates the silicon to correct the standby-power problem, it won't be possible to draw direct conclusions about the power efficiency of Cortex-M3 versus that of 8-bit MCUs.

However, we can make extrapolations by using data from ARM. ARM prefers taking performance into account when discussing power, because the ultimate criterion is power efficiency. But in this case, the assumption is that an 8-bit device delivers adequate performance. The question is whether a move to 32 bits incurs a prohibitive power penalty.

Of course, estimating power consumption is even more difficult when dealing with CPU cores, because a processor-IP company like ARM has little or no control over the peripherals that customers integrate with the core. ARM can only report the power used by the core in a specific semiconductor process. ARM has optimized the Cortex-M3 for power efficiency and says that power has dropped to 0.19mW per megahertz compared with 0.38mW per megahertz for an ARM7TDMI. Those numbers assume both cores are fabricated in a 0.18-micron TSMC G process.

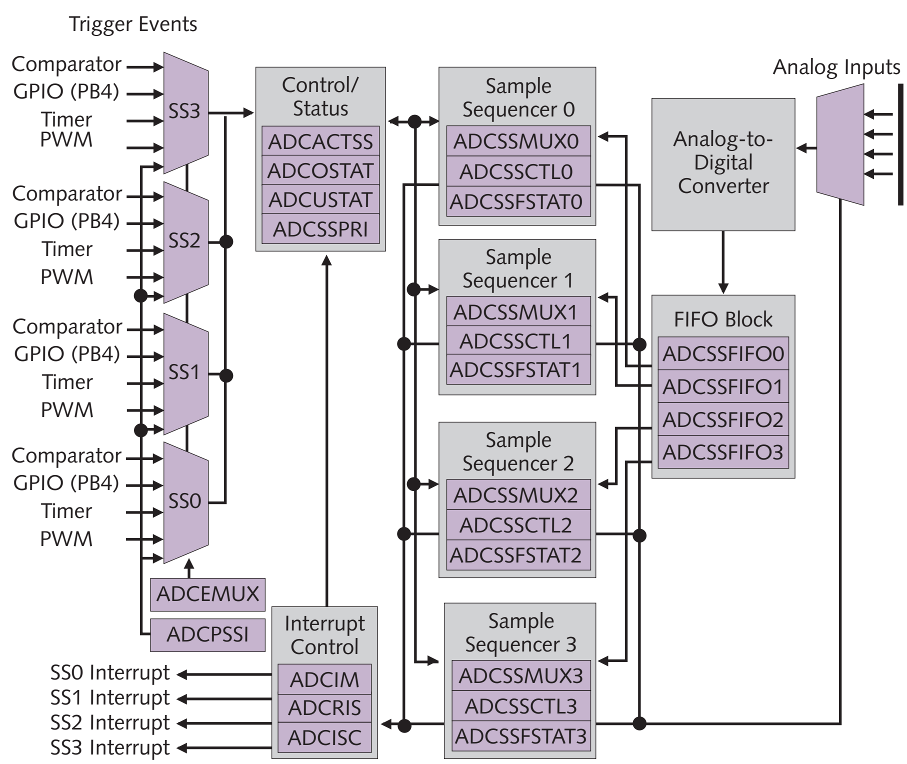

Figure 4. Although Luminary Micro purchased the mixed-signal block for the ADC, the engineers designed a set of sophisticated sequencers to give programmers more flexibility when sampling the analog channels.

Price & Availability

Luminary Micro's LM3S301, LM3S310, LM3S318, and LM3S316 are sampling now and are scheduled for volume production in 3Q06. Prices in 10,000-unit quantities are $2.53, $3.84, $4.37, and $4.62, respectively. For more information, see *www.luminarymicro.com*.

Making Power-Consumption Comparisons

For comparison with an 8-bit device, we chose the Atmel AT89LP, because it is an interesting MCU with an updated 8051 architecture that executes most instructions in a single cycle—almost a 10× improvement. Atmel markets these devices as low-power chips with active power consumption of 1mA at 3.0V and 1.0MHz. That's 3mW per megahertz for the entire chip, versus 0.19mW per megahertz active power for a Cortex-M3 core alone.

Of course, we're not comparing chips manufactured in the same process, but the magnitude of the difference indicates there isn't much active-power penalty for using 32 bits. The peripherals, memory, and I/O will burn a large percentage of the active power, regardless of the processor core.

Luminary Micro says that active power for the LM3Sxxx series at 20MHz and 3.3V is 35mA, which translates into 5.8mW per megahertz. However, this figure seems to include power for more peripherals than the Atmel device has. For a meaningful comparison with other MCUs, one must extrapolate those numbers for chips having identical peripherals. System designers on a tight power budget obviously have a difficult design challenge if they rely only on vendor datasheets.

Standby power is an entirely different issue, because it depends on the number of transistors, the device voltage, and the amount of transistor leakage for the process technology. Obviously, a 32-bit CPU architecture requires more transistors than an 8-bit architecture, which exacerbates leakage in standby mode.

The Stellaris devices use an external 3.3V supply and an on-chip regulator to supply 2.5V to internal logic circuits. Luminary Micro must move to a lower-voltage process to gain much improvement in power consumption. However, the advanced processes that allow lower voltage also begin to suffer more current leakage. High-end CPUs are combating this problem with sophisticated design techniques, but low-cost MCUs may not be able to afford the same tricks. In general, *MPR* concludes that 8-bit MCUs will continue to have a power advantage over 32-bit MCUs when in standby (sleep) modes.

Development Tools Are a Major Factor

Finally, we come to the elephant in the room. It is interesting to dissect 8- and 32-bit architectures from a technical

Feature	Luminary LM3S101	Luminary LM3S301	Luminary LM3S316	Philips LPC2101	Philips LPC2103	Atmel AT91SAM7S32	Oki ML67Q406x	Oki ML67Q500x
CPU Core	ARM Cortex-M3	ARM Cortex-M3	ARM Cortex-M3	ARM7TDMI-S	ARM7TDMI-S	ARM7TDMI	ARM7TDMI	ARM7TDMI
Frequency	20MHz	25MHz	25MHz	70MHz	70MHz	55MHz	33.3MHz	60MHz
Dhrystone MIPS	25 DMIPS	31.25 DMIPS	31.25 DMIPS	63 DMIPS	63 DMIPS	50 DMIPS	30 DMIPS	54 DMIPS
Integrated Flash Memory	8K On chip	16K On chip	16K On chip	8K On chip	32K On chip	32K On chip	64K or 128K On chip	256K or 512K In package
Flash I/F	32 bits	32 bits	32 bits	128 bits	128 bits	32 bits	32 bits	16 bits
SRAM	2K	2K	4K	2K	8K	8K	16K	32K
Ext Memory I/F	—	—	—	—	—	—	—	16 bits
RT Clock	Yes	Yes	Yes	Yes	Yes	Yes	Yes	—
Timers	2 + watchdog	2 + watchdog	3 + watchdog	4 + watchdog	4 + watchdog	3 + watchdog	7 + watchdog	7 + watchdog
I^2C Interface	—	—	1	2	2	—	1	1
SPI	1	1	1	2	2	1	2	—
UART	1	1	2	2	2	1	2	2
GPIO	Up to 18	Up to 33	Up to 32	Up to 32	Up to 32	—	Up to 40	Up to 42
Fast GPIO	Yes	Yes	Yes	Yes	Yes	—	—	—
ADC Channels	—	3	4	8	8	8	4	4
IC Process	0.25µm	0.25µm	0.25µm	0.16µm	0.16µm	0.18µm	0.22µm	0.22µm
Voltage (Core-I/O)	2.5V/3.3V	2.5V/3.3V	2.5V/3.3V	1.8V/5.5V	1.8V/5.5V	1.8V/5V	2.25V/3.6V	2.25V/3.6V
Power (typical)	116mW	145mW	145mW	70mW*	70mW*	95mW	n/a	290mW
Operating Temp	–40° to 85°C	–40° to 85°C	–40° to 85°C	–40° to 85°C	–40° to 85°C	–40° to 85°C	–40° to 85°C	–40° to 85°C
Package (size)	SOIC-28 7.6mm x 18mm	LQFP-48 7mm x 7mm	LQFP-48 7mm x 7mm	LQFP-48 7 x 7mm PLCC-44 17mm x 17mm	LQFP-48 7 x 7mm PLCC-44 17mm x 17mm	LQFP-48 7mm x 7mm	WCSP-64** 4.84 x 5.09mm TQFP-64** 10mm x 10mm	LQFP-144 20 x 20mm LFBGA-144 11mm x 11mm
Availability	Samples now Prod. 3Q06	Samples now Prod. 3Q06	Samples now Prod. 3Q06	Now	Now	Now	Now	Now
Price (10k units)	$1.00	$2.53	$4.62	$1.47	$2.20	$2.90	$3.98	$4.83

Table 3. Comparing some of Luminary Micro's Stellaris devices to existing ARM-based MCUs highlights the focus on low-end applications. Note that the estimates for typical power do not reflect direct comparisons with identical choices of peripherals. (*1mW per MHz, Philips estimate. **Also LFPGA-84, 9mm × 9mm.)

standpoint, but development tools often drive the purchase decision. If competing devices fit within the power, price, and code-size budgets, the system designers will almost always choose the one having the best hardware- and software-design tools. This is the reason Freescale is unifying its tools strategy across its MCU continuum, and it is the reason ARM acquired Keil, a popular vendor of MCU tools.

Luminary Micro is betting that most 8- and 16-bit MCU system designers would rather be using a modern 32-bit architecture that is optimized for high-level software development. In 2006, vendors will ship more than two billion ARM-based CPUs, and ARM expects that number to grow to 4.5 billion by 2010. This ubiquity is driving the growth of a huge ecosystem, and MCU system designers have a wealth of choices if they move to ARM.

About half of Luminary Micro's customers already use ARM processors and need MCUs for their systems. Rather than adopting a different MCU architecture, they went looking for an ARM-based MCU. Although Luminary Micro can take advantage of existing tools for the CPU core, the company chooses to invest heavily in software support for Stellaris peripherals, creating an extensive library of APIs and sample device drivers that allow users to quickly get a system running.

Competition From Other 32-bit MCU Vendors

Luminary Micro has an advantage over 8- and 16-bit MCU vendors if Stellaris MCUs fit the power budget, but the competition gets fiercer against other MCU vendors trying to move customers to 32 bits. The primary challenge is performance. Even the latest Stellaris devices that bump the clock speed to 25MHz are much slower than most other ARM-based MCUs.

Table 3 compares Stellaris MCUs with other MCUs based on the older ARM7TDMI processor core. And more competition is coming, because ARM has disclosed that three other vendors have licensed the Cortex-M3. Some of the new licensees are existing vendors of ARM-based MCUs.

As a startup, Luminary Micro can succeed by capturing only a small percentage of the $13 billion MCU market. Fortunately for a newcomer, there are so many diverse segments that no single vendor can possibly serve them all. Luminary Micro is relying on its distributors and sales representatives to find the system designers that need a low-priced, general-purpose MCU in moderate volumes. The tight relationship with third-party sales organizations is critical for a small company trying to compete with the huge sales and support networks offered by large semiconductor companies.

For a brief moment, Luminary Micro has the Cortex-M3 market to itself, and the company is moving quickly to exploit that lead. Several powerful companies are in hot pursuit, however, so Luminary Micro can't stop to rest. ◇

J. Scott Gardner is an engineer and consultant who began his career 25 years ago by designing microprocessor-based systems. His systems perspective became valuable later when he served in various marketing and management roles in the semiconductor industry, most notably during ten years at IDT. He has held executive-staff or board positions at several startups and continues to consult part-time while occasionally writing for technical publications.