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LinkUp Systems Brushes Bluetooth

ARM-Based L7205 Is Enhanced for Short-Range Wireless Technology

By Tom R. Halfhill {8/21/00-01}

LinkUp Systems is sampling an embedded processor that's "Bluetooth ready"—a pitch that sounds suspiciously like advertising stereo speakers as "digital ready." And indeed, LinkUp's new L7205 stops far short of integrating everything necessary to implement a Bluetooth radio transceiver without using additional components. But LinkUp says the USB interface and souped-up UARTs on the L7205 can nibble a few dollars off the cost of a typical Bluetooth implementation.

Bluetooth appears to be the up-and-coming solution for reducing or eliminating the tangles of cables on PCs, peripherals, PDAs, cell phones, and other digital devices (see *MDR 6/1/98-08*, "Bluetooth Creates Personal Wireless Network"). Operating in the 2.4GHz range, Bluetooth is intended for short-range (10 meters, or 100 meters with amplification), low-bandwidth (721Kb/s) communications, either point-to-point or point-to-multipoint. The latter mode allows a PC to interface with several peripherals, or a small group of people to establish an ad hoc network of PDAs.

Adding Bluetooth capability to a product currently requires a module with a radio transceiver, antenna, and ROM for the protocol stack. (Bluetooth uses its own frequency-hopping, packet-switching protocol with encryption.) The modules are available from various companies, including Ericsson, which dreamed up the idea for Bluetooth. Someday, a complete Bluetooth solution will be integrated on a single CMOS chip. For now, the modules are the only way to go, and their relatively large size (about 1.5 inches square) and high cost ($20–$50) make them impractical for many products that could benefit from Bluetooth.

Unfortunately, LinkUp's L7205 doesn't change that situation. Instead, it offers two options for attaching a Bluetooth module to an embedded system: fast UARTs or USB. The

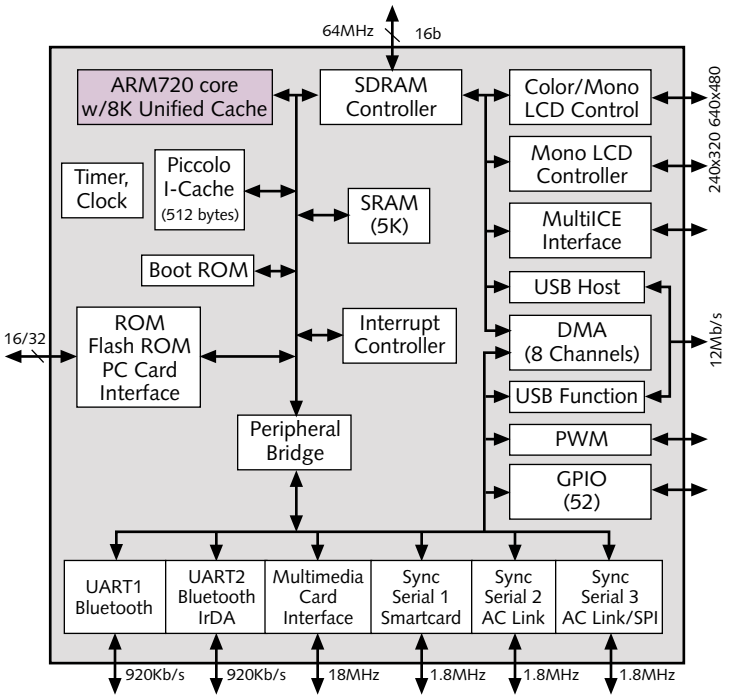

Figure 1. LinkUp's L7205 is a highly integrated chip based on an ARM720T processor core with a Piccolo DSP coprocessor. The ARM core supports compressed Thumb instructions for greater code density.

L7205 is an enhanced version of the L7200, which entered production earlier this year. The two major differences between the chips are that the L7205 has a USB interface and a pair of high-speed UARTs. While the UARTs on the L7200 are limited to the usual 115Kb/s, the L7205's UARTs can handle 920Kb/s. That feature allows system designers to attach a Bluetooth module to the USB interface or either UART.

The UARTs are the logical interface for a product that has a built-in Bluetooth module, especially if it's desirable to leave the USB interface free for other purposes. USB is a better solution for products designed to work with an add-on Bluetooth module.

A Rare Piccolo Performance

Like its predecessor, the L7205 is based on an ARM720T processor core. The L7205 and L7200 are among the few ARM7 designs to include a Piccolo DSP coprocessor (see *MPR 11/18/96-04*, "ARM Tunes Piccolo for DSP Performance"). Although Piccolo has a useful DSP instruction set, it's relatively difficult to work with and was shunned by most ARM customers. At last year's Embedded Processor Forum, ARM announced the ARM9E core, which adds DSP extensions to the regular instruction set without using a coprocessor (see *MPR 6/21/99-03*, "Arm Refocuses DSP Effort"). By then, LinkUp had already started designing around Piccolo and didn't want to wait for the ARM9E.

The L7205's core frequency is 64MHz at 3.3V or 36MHz at 2.7V. The chip's fully static core retains data down to 1.8V. Typical power consumption at 3.3V is 350mW, and performance is a respectable 60 Dhrystone 2.1 mips at 64MHz. LinkUp's primary foundry partner is Hyundai Microelectronics, and TSMC is another partner. Hyundai is fabricating the L7205 in a 0.35-micron CMOS process and is packaging the die in a 280-contact FBGA that measures 16mm square. It's pin compatible with the L7200. The L7205 is sampling now and will enter production next month. In 10,000-unit quantities, the price is $24.50, or $3 more than the L7200.

As Figure 1 shows, the L7205 surrounds the ARM720T core with a cornucopia of peripherals. There's an SDRAM controller; a glueless interface for other memory types (ROM, flash ROM, or PC Cards); two LCD controllers (one for 16-bit color screens at 640 x 480 pixels, and the other for 4-bit monochrome screens at 240 x 320 pixels); an eight-channel DMA controller; a USB interface (including a host controller and a transceiver); and the dual high-speed UARTs mentioned above. There are also 52 general-purpose I/O ports, a multimedia card controller, and three synchronous serial channels that support a smart-card interface, AC Link stereo audio, and a serial peripheral interface (SPI).

In addition to the 8K unified cache in the ARM720T core, there's a 512-byte instruction cache for Piccolo and 5K of scratchpad memory. With the addition of a $1.25 codec, the AC Link–compatible synchronous serial channels will support a 16-bit stereo audio interface. LinkUp has an MP3 software decoder for customers wishing to design an Internet-audio player around the L7205. The company also offers code for V.32bis-, V.34-, and V.90-standard soft modems.

LinkUp already has some design wins for the L7205 and L7200, including a smart-phone/wireless-Internet terminal, a PDA, a screen phone, and a set-top box. Some of those customers haven't disclosed their products yet. One that has is Askey Computer in Taiwan, which is using the L7200 for an under-$200 Windows CE organizer that will debut in Europe later this year. IPM, an Italian company, is using the L7200 in a screen phone that runs Windows CE. LinkUp is working on some reference designs, including a set-top box with a bill of materials under $100.

In addition to Windows CE, both the L7205 and the L7200 can run five other

Feature	Link-Up L7205	Link-Up L7200	Cirrus Logic EP7212	Cirrus Logic EP7211	Cirrus Logic EP7209
CPU Core	ARM720T	ARM720T	ARM720T	ARM720T	ARM720T
Piccolo DSP?	Yes	Yes	No	No	No
Core Frequency	64MHz	64MHz	74MHz	74MHz	74MHz
On-Chip SRAM	5K	5K	37.5K	37.5K	37.5K
DRAM Control	SDRAM	SDRAM	EDO	EDO	—
LCD Control	640 x 480 color 240 x 320 mono	640 x 480 color 640 x 480 mono	1024 x *n** mono	1024 x *n** mono	1024 x *n** mono
ROM/Flash-I/F?	Yes	Yes	Yes	Yes	Yes
USB Host Controller?	Yes	No	Yes (via serial I/O)	Yes (via serial I/O)	Yes (via serial I/O)
USB Transceiver	Yes	No	No	No	No
Smart Card I/F?	Yes	Yes	No	No	No
MM-Card I/F?	Yes	Yes	No	No	No
16-Bit Stereo Audio?	Yes	No	Yes	No	Yes
UARTs	920Kb/s x 2	115Kb/s x 2	115Kb/s x 2	115Kb/s x 2	115Kb/s x 2
PWM?	Yes	Yes	Yes	Yes	Yes
GPIO	52 ports	52 ports	27 ports	27 ports	27 ports
IrDA?	Yes	Yes	Yes	Yes	Yes
ICE/JTAG?	Yes	Yes	Yes	Yes	Yes
PC-Card I/F?	Yes	Yes	No	No	No
IC Process	0.35µ	0.35µ	0.25µ	0.25µ	0.25µ
Voltage	3.3V/3.3V	3.3V/3.3V	2.5V/3.3V	2.5V/3.3V	2.5V/3.3V
Power (typical)	350mW	350mW	90–150mW	90–150mW	90–150mW
Price (10K)	$24.50	$21.50	$17–$19.50 †	$16–$18 †	$13.50–$16 †
Availability	September	Now	Now	Now	Now

Table 1. LinkUp's L72xx chips resemble Cirrus Logic's Maverick EP72xx processors, with interesting tradeoffs of features, performance, power consumption, and prices. *Resolution depends on the size of the frame buffer. †Prices vary according to package types.

operating systems: EPOC32 (Symbian), Nucleus Plus (Accelerated Technology), Royal Linux (Integrated Software & Devices), mITRON (Wind River), and VxWorks (Wind River).

LinkUp's roadmap shows a third member of the L72xx family, the L7210, which will be manufactured in a 0.18-micron process later this year. The process shrink—which skips the 0.25-micron generation altogether—should drop power consumption below 100mW.

Price & Availability

LinkUp Systems' L7205 is sampling now and will be available in production volumes in September. In 10,000-unit quantities, the price is $24.50. The L7200 is available now for $21.50. For more information, go to *www.linkupsys.com*.

Distant Cousins Are Close Competitors

Except for custom ASICs, the closest competitors to LinkUp's L72xx chips are Cirrus Logic's Maverick processors (see *MPR 11/15/99-03*, "Cirrus Logic Makes Music With ARM"). There's almost a family resemblance—perhaps because great minds think alike, or perhaps because most of LinkUp's engineers came from the Cirrus Logic design team that created the ARM chips for Apple's Newton. (LinkUp, based in Silicon Valley, was founded in 1997.)

The Maverick EP7209, EP7211, and EP7212 use the same ARM720T core as LinkUp's L7205 and L7200, though without the Piccolo DSP. Cirrus Logic aims the Mavericks at the same markets, especially PDAs and MP3 players. Because Cirrus Logic builds the Mavericks in a more advanced 0.25-micron CMOS process, they have a clock-frequency and power-consumption advantage over the L7205 and L7200. The Mavericks reach 74MHz at 2.5V (with 3.3V-tolerant I/O) and typically consume only 90–150mW, less than half as much power as the L7205. LinkUp says its power ratings are not comparable with Cirrus Logic's, because the L7205 and L7200's consumption was measured while running a color LCD rather than a monochrome display. Furthermore, the L7205 and L7200 have a separate power rail for the SDRAM interface, allowing some systems to shut off the external memory altogether after backing up the data on flash ROM. Even so, PDAs and MP3 players that have monochrome screens and don't take such extreme measures will no doubt consume less power using a Maverick chip. Table 1 summarizes the similar features of these chips.

In some applications, the Mavericks' 15% advantage in clock speed over the L7205 and L7200 won't compensate for their lack of a Piccolo coprocessor. DSP-intensive algorithms will run faster on Piccolo. That's not necessarily a win for software developers, however, because the ARM9E's DSP instructions appear to be the favored migration path for future ARM-based chips.

Maverick processors have a lot more scratchpad memory on chip: 37.5K of SRAM vs. 5K of SRAM in the L7200 and L7205. That's enough memory to buffer an audio stream for MP3 decoding or a 640 x 240-pixel LCD screen with two bits of gray scale. LinkUp's chips require external memory for those buffers. But LinkUp's DRAM controller supports SDRAM, while the Maverick DRAM controller is limited to older EDO and fast-page DRAM. (Future Mavericks will support SDRAM too.)

The L7205 and L7200 partly compensate for their smaller on-chip memories by using a unified memory architecture; they store the frame buffer in main memory. Normally, this would reduce performance, because the CPU has to access video memory and program memory over the same bus. LinkUp averts this bottleneck by providing separate datapaths to video memory and program memory, and by managing memory transfers with a DMA controller. By eliminating the need for a separate frame buffer and allowing DMA transfers without CPU intervention, the L7205 and L7200 can use a lower-cost memory subsystem that potentially consumes less total power than other solutions.

Both families of processors are equally well endowed with on-chip peripherals. Although the Mavericks don't have the L7205's fast UARTs, developers can attach a Bluetooth module to Maverick's 32-bit serial I/O bus. The L7205 could accommodate a Bluetooth module on either UART and leave the USB interface free for other devices.

Overall, the Mavericks offer similar features and slightly higher performance for less money, except for applications that need a DSP. The additional cost, power consumption, and design complexity of a discrete DSP would make a Maverick-based solution less attractive.

In truth, it's hard to go wrong with any of these chips. If their peripheral integration fits the target application, all of them are good off-the-shelf alternatives to the longer design cycles and higher nonrecurring engineering costs of ASICs.

What embedded developers really need, though, is a low-cost single-chip Bluetooth device that includes the radio transceiver, protocol ROM, and other necessities—or, better yet, a variation of the L7205 that integrates those functions on chip. Until someone fills that cavity, the relatively high cost and bulk of Bluetooth modules will slow the adoption of this useful technology. ◇