Texas Instruments

EXTENDING YOUR REACH™

TI's standard-independent, single-chip digital baseband platform for wireless system design

Texas Instruments single-chip Digital Baseband Platform, combines two high-performance core processors — a digital signal processor tailored for digital wireless applications and a microcontroller designed specifically for low-power embedded systems. The customizable platform helps wireless digital telephone manufacturers lower component counts, save board space, reduce power consumption, introduce new features, save development costs and achieve faster time to market, at the same time giving them flexibility and performance to support any standard worldwide.

Technology Brief

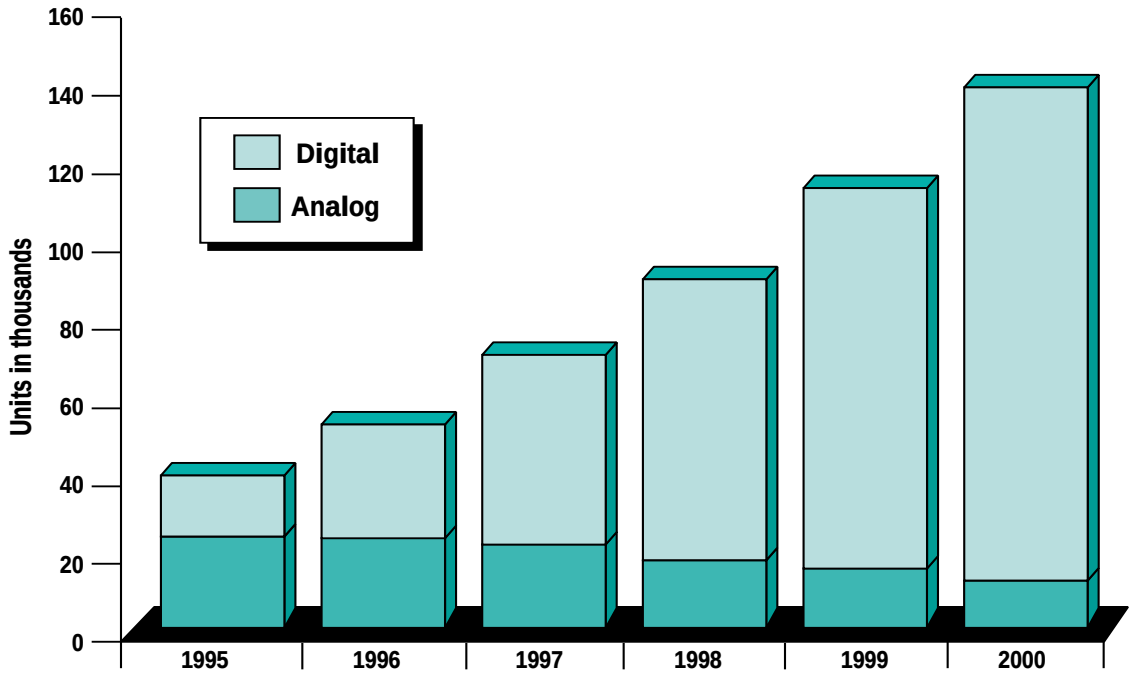
Introduction

Communications today is on the move. In cars, office buildings, manufacturing plants, shopping malls — wherever people go, wireless telephones and other communications systems go with them. Driving this new mobility in communications is high-speed digital technology, and in the forefront of this technology is Texas Instruments, the industry leader in Digital Signal Processors (DSPs) and DSP Solutions.

Digital technology opens up a world of new possibilities for mobile communications. With three to ten times the transmission capacity of older analog technology, digital allows more wireless subscribers to place telephone calls simultaneously. Digital technology also consumes less power than analog, extending talk and standby times between battery charges. And digital encryption enhances security for users and service providers alike.

It is small wonder that digital wireless telephones are the fastest-growing segment of the wireless telephone industry. As Figure 1 shows, by the end of the decade more than 80 percent of the cellular and Personal Communications Systems telephones sold will be digital.

Digital technologies drive wireless telephone production



Source: Dataquest, September 1996

Figure 1. In the fast-growing market for wireless telephones, digital technology is rapidly overtaking analog as the technology of choice.

Meeting the needs of next-generation systems

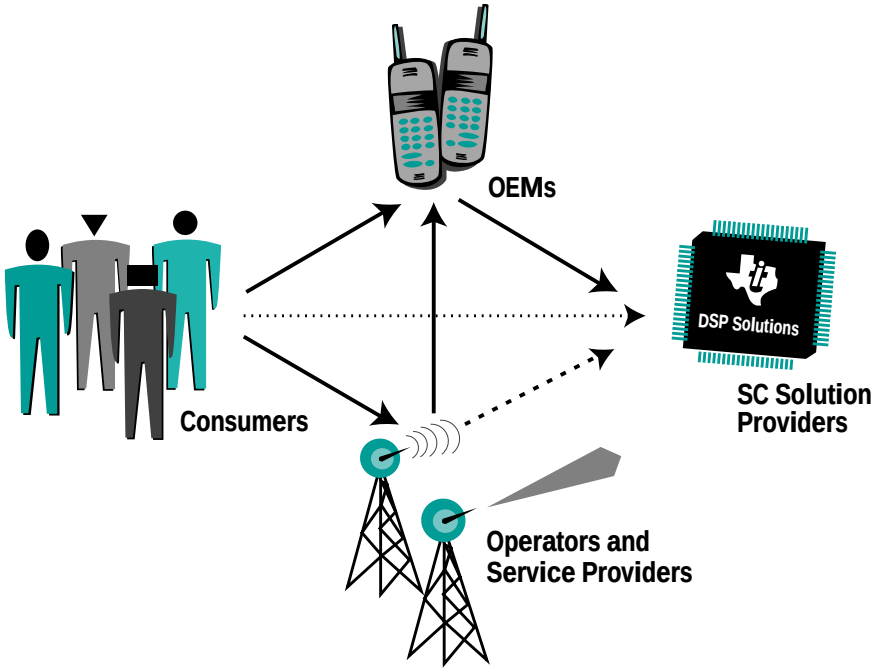


Figure 2. TI works with its customers to understand the requirements of their markets, and supplies the technology that enables OEMs to meet the needs of wireless users and service providers.

Market requirements for digital wireless telephones

Figure 2 shows that wireless telephones are strongly influenced in design by the needs of individual consumers, service providers and original equipment manufacturers (OEMs). Generally, users want small, lightweight instruments that cost little and allow them to talk for a long time between battery charges. Although callers accept some degradation in voice quality as a tradeoff for mobility, they still regard voice quality as crucial. In addition, callers frequently want extra features, such as greater privacy and the capability to transmit data.

Service providers respond to the requirements of their subscribers, and in addition they have requirements of their own. These include the need for high capacity and low usage costs to help them expand their services and maximize profits. Providers want compact base stations that do not require special cooling arrangements. Additional user features also serve as a new source of revenue for service providers. Finally, all equipment and services must be fully compliant with standards, and secure to prevent fraud.

Worldwide digital wireless standards

	Digital Cellular	Digital Cordless	Paging
North America	• IS-95 (800, 1900) • IS-54/136 (800, 1900) • PCS1900	• Unlicensed 900 MHz ISM • PACS	• FLEX™ • ReFLEX™ • InFLEXion™ • PACT
Europe	• GSM • DCS1800	• DECT	• FLEX • ReFLEX • InFLEXion • Ermes
Japan	• PDC • PDC1500	• PHS	• FLEX • ReFLEX • InFLEXion
Asia – Pacific	• GSM • IS-95 • IS-54/136	• DECT • PHS	• FLEX • ReFLEX • InFLEXion

Table 1. Flexibility in baseband subsystems is important for OEMs to support the variety of digital wireless standards and applications worldwide.

In order to satisfy consumers and service providers, OEMs of wireless phones and base stations must base their products on low-cost, high-performance components featuring a high level of system integration, low power consumption and advanced packaging. For wireless digital telephones, OEMs require the processing performance of advanced DSPs, combined with a flexible upgrade path for future product development and backed by DSP and microcontroller software supporting digital standards.

A great challenge to OEMs is handling the variety of digital wireless standards and applications. Transmission standards, summarized in Table 1, vary widely in different regions of the world. Flexibility in baseband subsystems is critical for OEMs to support not only the variety of mature standards, but also developing standards, such as those used for the new all-digital PCS frequency band. In addition, new applications for wireless technology are appearing all the time, including two-way voice and data paging, local-area wireless phones in pedestrian areas such as shopping malls, and dual-mode phones that operate from a cordless exchange inside a plant or office building and with mobile cellular or PCS connections elsewhere for full user mobility.

Ultimately, the enabling technology to satisfy all these requirements must come from an IC vendor like Texas Instruments, which has the advanced processes and products required for low operating voltages, high performance and system-level integration. TI's advanced DSP architectures provide the high-powered but efficient processing needed for wireless applications. With its system expertise, software modules and advanced packaging options, TI brings systems together with high-level solutions that enable OEMs to satisfy the needs of consumers and service providers. OEMs also rely on TI's manufacturing strength for fast time to production, a secure high-volume supply and industry-leading test and emulation capabilities.

The importance of the digital baseband section

The heart of a digital wireless system is the digital baseband section — important not only for its high-performance processing, but also because high levels of integration in the digital baseband section can significantly reduce system cost and power consumption.

Figure 3 shows a block diagram with the three subsystems of a digital wireless telephone. The radio frequency (RF) section receives the incoming analog phone signal and converts it to a low-frequency baseband signal by stripping away the RF carrier. To transmit outgoing signals, the RF section reverses this process.

Digital wireless telephone block diagram

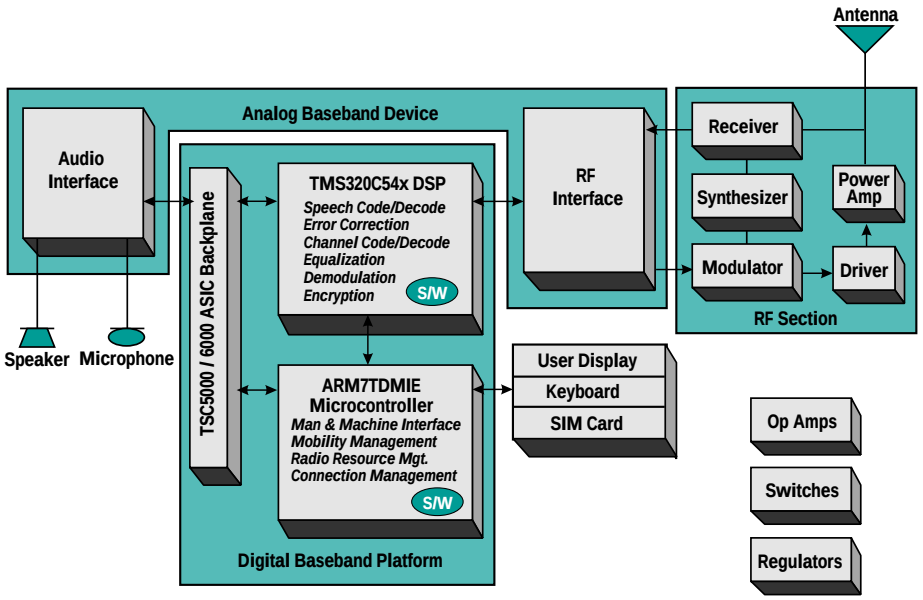


Figure 3. TI's Digital Baseband Platform works with other TI mixed-signal devices to provide a highly integrated solution for digital wireless systems.

The analog baseband section converts the baseband signal it receives from the RF section into a digital signal, which it sends to the digital baseband section for further processing. After the digital signal processing is complete, the analog baseband section converts the digital signal back to analog for output to a speaker. For incoming signals from the microphone, the process is reversed.

The digital baseband section performs the high-speed digital signal-processing functions of digital wireless telephony. These typically include:

- Speech encoding and decoding
- Error Correction
- Channel encoding and decoding
- Equalization
- Demodulation
- Encryption

In addition to DSP functions, there are other digital functions in the digital baseband section that today are more efficiently handled by a microcontroller. These functions include:

- Real-time operating system
- Human-machine interface (keyboard, ringing, etc.)
- Mobility and network management

Although these functions are common to all systems using all transmission standards, they are handled differently by each.

A flexible, fully integrated digital baseband solution

TI's Digital Baseband Platform integrates all the digital components needed for digital wireless phones in a single-chip customizable DSP Solution. At the heart of the platform are two complementary digital processing engines — a TMS320C54x DSP and a 32-bit TMS470 microcontroller unit (MCU) based on the industry-standard ARM7TDMI™ (Thumb™) design licensed from Advanced RISC Machines LTD. The processor cores can be programmed to support any digital wireless protocol, so the platform can be used to design systems for use in any region of the world.

As Figure 4 shows, the 'C54x DSP core is tailored to the processing needs of digital wireless phones. With an architecture optimized for wireless applications, the 'C54x core includes:

- A Viterbi accelerator for enhanced performance in key wireless algorithms
- Four internal buses and dual address generators that enable multiple operand operations and reduce memory bottlenecks
- A 40-bit adder and two 40-bit accumulators that support crucial parallel instructions for execution in one instruction cycle
- Single-cycle normalization and exponential encoding to support floating-point arithmetic subroutines for voice coding
- 16-signed or 17-bit unsigned multiplication in one instruction cycle
- New single-cycle instructions for execution of common DSP tasks
- A 40-bit ALU with dual 16-cycle configuration capability for dual one-cycle operations
- Eight auxiliary registers and a software stack to enable the industry's most advanced fixed-point DSP C compiler

TMS320C54x DSP core architecture

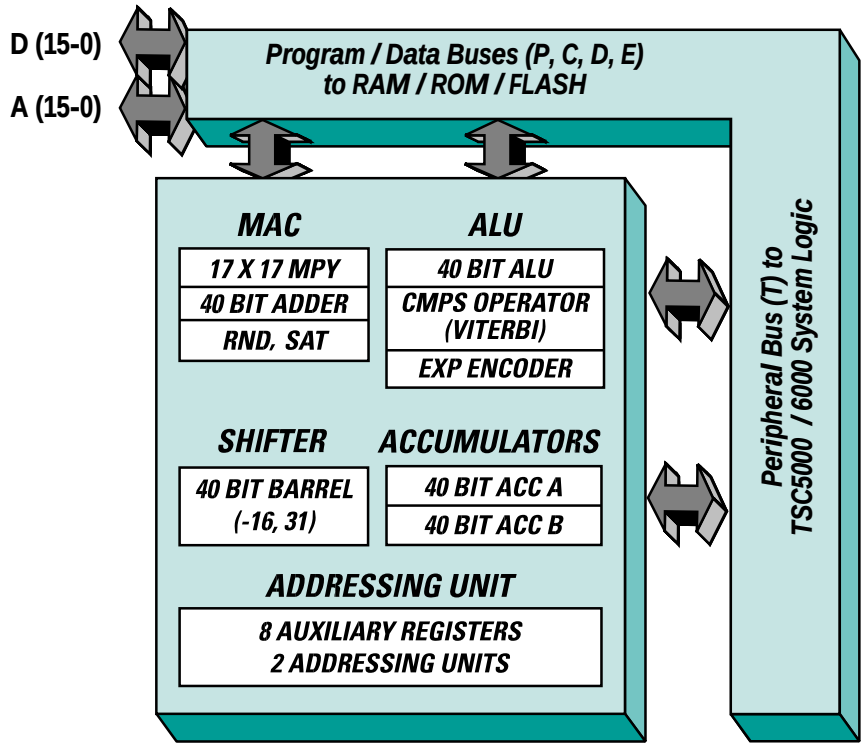


Figure 4. TI's 'C54x DSP core is optimized to meet the needs of digital wireless applications.

TMS470 MCU core architecture

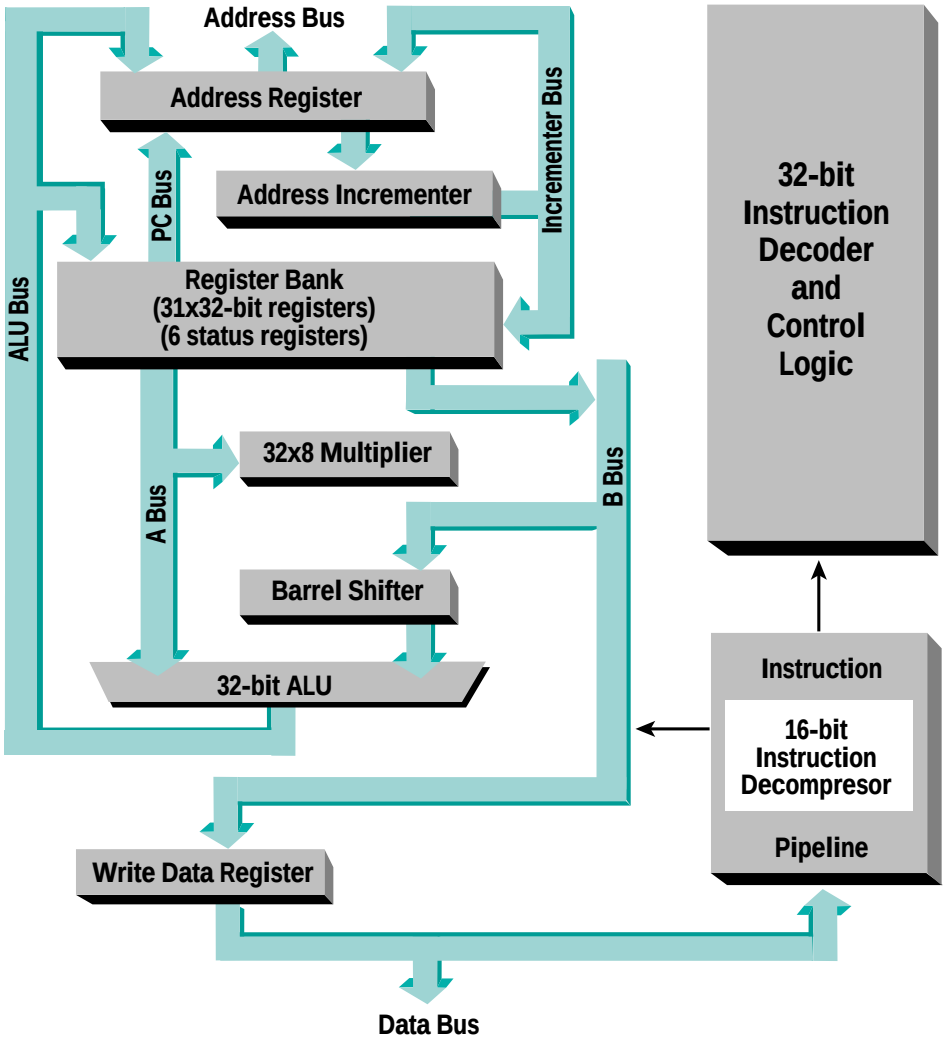


Figure 5. TI's TMSc470 MCU core is small, low-power and high-performance — ideal for wireless embedded systems.

Figure 5 shows that TI's 'c470 core is well suited to the needs of low-power, high-performance embedded systems such as wireless phones. Operating at up to 75 MHz, the core features two RISC instruction sets: 32-bit instructions for execution, and 16-bit instructions for savings in memory space. The 16-bit instructions are expanded to 32 bits internally for execution. Combined with the inherent compactness of the design, this dual instruction set saves a remarkable amount of memory space and expense, as well as giving designers much-needed flexibility in code development.

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The MCU is also extremely compact and low in power dissipation. A 0.25-micron version, compatible with the TSC5000 ASIC library and operating at 2.5 V, is estimated at 2 square mm on the die (about one-third the size of similar MCU cores).

Using TI's application-specific integrated circuit (ASIC) design methodology, system designers can integrate additional logic functions, RAM, ROM and Flash memories, and some mixed-signal functions such as phase-locked loops, analog-to-digital and digital-to-analog converters. The platform is supported by TI's 0.25-micron CMOS TSC5000 Standard Cell ASIC library. TI plans to migrate designs in 1997 to the 0.18-micron TSC6000 library, which is based on TI's 125-million-transistor TImeline™ technology. Along with ever-diminishing transistor geometries will come enhancements in mixed-signal integration, making possible future platforms that include high performance analog baseband and even RF functions on a single chip.

TI software support simplifies platform development for wireless customers. DSP vocoder modules are available for various wireless transmission standards, and MCU software modules for all standards are either available or in development. TI's standard TMS320 development tools, along with the industry's leading selection of third-party tools and algorithms, support code development for the DSP core. The MCU is supported by two tool suites: one that is compatible with other TI MCU and DSP families, and another licensed from ARM. In addition, real-time operating systems for the MCU are available from leading third-party suppliers.

Both cores are accessible for in-circuit emulation (ICE) through an IEEE 1149.1/JTAG test port. Special on-chip logic allows simultaneous co-emulation of both cores with a single set of emulation hardware. This unique, proprietary co-emulation capability from TI can save designers months of development time, speeding time-to-market.

A single-chip digital baseband platform

With its high level of system integration, TI's Digital Baseband Platform offers a single-chip DSP Solution that saves board space, lowers component counts and reduces cost. With its support for any wireless digital standard, the digital baseband platform is designed for flexibility, allowing OEMs to differentiate their products and stay ahead in the market. Figure 6 shows a typical implementation of the platform.

Digital Baseband Platform implementation

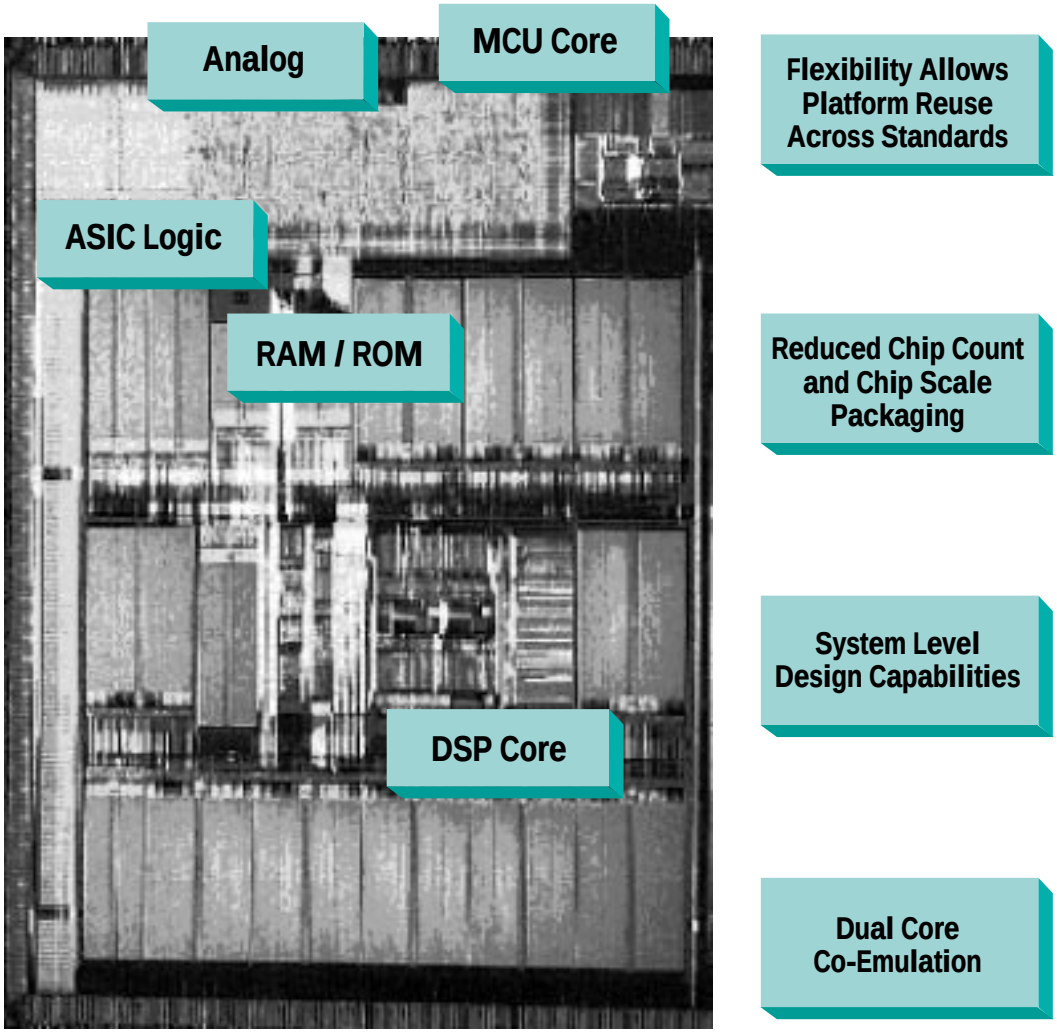

Figure 6. TI's Digital Baseband Platform combines all the digital baseband functions of a wireless digital telephone on a single customizable chip.

The platform's low power dissipation helps prolong battery life and allows systems to run on smaller, lighter-weight batteries. Power savings in the future promise to be even greater: TI estimates that digital baseband power requirements with 0.18-micron CMOS technology will be reduced more than 90 percent from today's technology.

The 'C54x DSP will also continue to improve in performance. TI has demonstrated 3-volt 'C54x DSPs operating at 100 MIPS, and it plans to offer these in production quantities during 1997. Higher DSP performance will allow systems to support enhancements such as higher compression algorithms to improve capacity or vocoder algorithms that improve voice quality. Other possible system enhancements include support for more than one transmission standard, or new features such as voice dialing.

TI's advanced packaging options include thin quad flatpacks (TQFPs) and small ball-grid arrays (BGAs), saving system space and cost. Industry-leading field and factory support, including tools and software modules, helps manufacturers get to market faster with improved products.

Wireless communications leadership

The digital baseband platform illustrates why TI has become a major solutions supplier for digital wireless systems. As the world's leading DSP and DSP Solutions provider, the company has a strong focus on wireless applications and is engaged with the leading wireless OEMs of both handsets and base stations.

Today TI is shipping large volumes of DSPs, cDSPs and custom ASICs to wireless customers worldwide for phones, pagers and base stations. TI expects to ship approximately 22 million DSPs or cDSPs into digital wireless phones in 1996, representing more than half of the market. In addition, the company supplies RF and analog baseband components that are compatible with the digital baseband platform, and it is continually enhancing its product offerings in these areas, too.

A wide array of Digital Signal Processing Solutions, advanced integration technologies and system-level expertise gained from working with industry-leading customers help TI's worldwide business structure meet the needs of its wireless customers and enable new developments in the wireless communications industry.

For more information on Texas Instruments Wireless Solutions, visit http://www.ti.com/sc/docs/wireless/home.htm on the worldwide web.

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