DSP
Texas Instruments
DSP Solutions

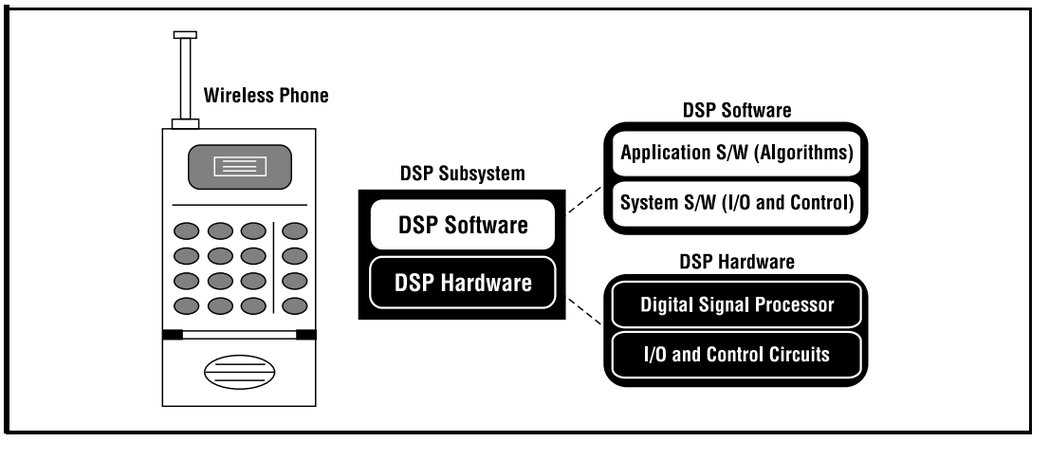
Getting Started With Digital Signal Processing for Telecommunications and Multimedia Applications

Overview

Telecommunications, multimedia, and consumer electronics products use digital signal processing (DSP) to compress, communicate, and modify signals. The *signals* are most often audio, video, and data signals. These signals contain too much information for practical communication and for low-cost storage devices such as digital answering machines. Also, communication service providers want to offer as many billable user lines as possible on each digital link. As a result, compression is employed to greatly reduce the amount of information required to communicate and store audio, video, and data. DSP is also used to enhance audio and video quality by reducing echo and noise. Telecommunications, consumer electronics, and multimedia products perform signal compression, communication, and enhancement using DSP subsystems.

A DSP subsystem is the portion of a product that performs the digital signal processing; the signal analog/digital conversion, compression, communication, or enhancement. The components of a DSP subsystem are the DSP hardware and the DSP software. DSP hardware consists of input/output and control circuits, and the digital signal processor. Digital signal processors, or DSPs, are microprocessors with enhanced mathematical capabilities for signal processing. Many DSPs are simpler than PC microprocessors, which makes them less expensive, and therefore, viable for consumer markets. The enhanced mathematical capability of DSPs allows them to perform very complex DSP tasks for products in many markets.

Software provides functionality to the DSP subsystem. Subsystem software consists of two different types of software integrated together: the *application software* that performs the DSP functions, such as signal compression, and *system software* that controls the system and its I/O devices. A useful analogy for application and system software is the PC environment. Word processing, accounting, and drawing programs offer the primary functionality of a PC and are called application software. DOS or Windows operates the system and its I/O devices and is called system software, or operating system software. Thus, the DSP



subsystem is a specialized, low-cost computing unit capable of implementing complex DSP tasks via application and system software.

Digital Signal Processors

There are two types of DSPs: those which perform fixed-point calculations and those which perform floating-point calculations. Fixed-point digital signal processors are lower cost but offer a very limited numerical dynamic range such as values from 0 to 65,536. To compensate, fixed-point software developers must make a major effort to scale numbers within each application. The numerical engineering effort can be as extensive as developing the application itself. Floating-point processors offer a very large numerical dynamic range such as values from 0 to 4,294,967,296 but are more expensive. The floating-point processor's numerical precision makes software development easier, but their cost and power consumption are higher.

When a DSP is chosen independently, the DSP with best architecture will be selected but not necessarily the DSP that is part of the best solution for cost, product functionality, and time to market. Additionally, the chosen DSP should come from a silicon company that has a track record of timely delivery. Many projects are seriously compromised by the silicon company production and delivery problems. The DSP should be selected by comparing total solutions, which necessarily includes the DSP software.

DSP Software

All DSP subsystems require system software to initialize and operate the processor and I/O devices, and to manage the processor's resources and applications. System software for single-processor products is often developed by the product manufacturer. The advantage to manufacturer-developed system software is direct control over value-added features that extend beyond the DSP functions. These value-added operational features often differentiate a product from its competitors. If a manufacturer is not able to support a software development staff, it may contract a DSP software company, or a consultant, to develop the system software. It's best if both the application and system software are developed by a single company.

Subsystems containing multiple DSPs commonly require more sophisticated task and resource management found in off-the-shelf DSP system software. Such packages provide a resource management infrastructure for processing multiple data channels on multiple processors with multiple applications. Even given an off-the-shelf DSP operating system, some system software must be developed (by the manufacturer or a contractor) to operate the I/O devices, applications, and features that are specific to a product.

Software applications consist of DSP algorithms that provide the primary functionality to a DSP product. Properly developed applications are processor specific and platform independent. They are coded as library function calls with minimized, well-structured interfaces for simple integration. Such applications should also be optimized for the target DSP, and should make minimal assumptions about I/O devices.

Application software can be very scientific and sophisticated. Voice compression and modem algorithms require many man-years of development and testing, and introduce high risk into DSP product development. For this reason, OEMs (and equipment manufacturers *or EMs*) purchase the application software from a DSP software company.

Several DSPs are supported by application software companies. However, certain DSP product lines have a distinct advantage over others. The leading DSP chip lines are strongly supported by both application software and top-quality development tools:

compilers, math libraries, development boards, and more. In order to get a product to market and make it succeed in that market, a manufacturer needs readily available (preferably off-the-shelf), well designed, high-performance application software.

When the DSP market was emerging, manufacturers were forced to develop their DSP algorithms themselves. This was very costly and time consuming. The development of these algorithms requires signal processing, numerical analysis, and real-time software engineering expertise to develop. As the DSP market evolved, DSP software companies were established to offer DSP applications and engineering services for system software development. Some of these companies offer a wide range of well-engineered DSP subsystem *solutions* in addition to individual algorithms and system software services. DSP software solutions are market specific, integrated application and system software packages that are customized to a range of possible hardware platforms. Turn-key software packages and algorithms get products to market for manufacturers with or without DSP expertise.

Designing a DSP Subsystem

To design a DSP subsystem, it's best to start with the product requirements and a DSP software company. Such companies offer DSP expertise as a pre-sales service. They typically recommend a solution consisting of a particular processor, set of software applications, and system software. Your selection should be made between solutions, not simply between processors or software application modules. The important criteria in choosing a solution are:

- Time to market (including your development time and software/hardware availability)
- Product functionality and performance
- Per unit cost (including time to market)
- Flexibility
- Risk

Different solutions have different times to market. For example, a floating-point DSP subsystem typically takes much less time to develop than a fixed-point DSP subsystem. In-house system software typically requires more time to develop than system software developed by a software company. The silicon vendor's ability to deliver their DSPs directly affects the prototype development and manufacturing schedules. Most importantly, the availability of software should be seriously considered before deciding upon a design.

A product is differentiated on the market by functionality, price, and performance. However, the product's success is not necessarily directly related to the success of its components. As an OEM or end-product manufacturer, the viability of your solution must be considered. Too often engineers choose a DSP processor because of its nice architecture and find their projects stalled indefinitely due to the lack of available application software, poor development tools, or higher production costs.

Software is typically the key to the solution for production volumes under 100k units per year. The hardware cost is only critical to the success of a product with production volumes significantly higher than 100k units per year. In such cases, the high volume manufacturer can amortize software development costs over the life of the product. However, if a higher priced product reaches the market nine to twelve months ahead of another, it may be able to control that market, especially if its price is reduced later. Readily available third-party software can make products successful in time sensitive markets and generally cost significantly less than internally-developed software.

DSP Software Companies

As the DSP market matures, more companies are contracting DSP software companies to deliver turn-key, integrated software packages, significantly reducing time to market. For the OEM, the higher the level of DSP subsystem integration the better. The ideal OEM/EM product is a market-specific, single-chip software solution that can be customized to the manufacturer's requirements.

Choosing a software partner can be critical to the success of a DSP product. The hardware represents advanced silicon technology, but is only the infrastructure of your product. The differentiating aspects of your product are most often implemented in software. Well designed, readily available software is found from a software partner.

Look for a partner that offers software for both fixed- and floating-point DSPs. The DSPs supported by their software line should be low cost in production. Any software, purchased or developed, should be engineered well. Algorithms should be designed with consistent, simple conventions for easy system integration and test. Poorly engineered software costs OEMs and EMs. Software bugs take more time to find and fix, and functional enhancements take more time to implement. The additional time results in reduced profits. A good software company offers high technology for cost-effective DSPs and a significant off-the-shelf product offering to minimize time to market.

Application software companies are now offering market-specific, highly-integrated software solutions. Presently one can find such solutions for answering systems and higher bandwidth multiplexers. However, many sophisticated and highly integrated solutions are only available in the form of DSP cards. As the market evolves, the newer and more sophisticated software migrates to cards, then to chips, and eventually to ASICs. The newest technology is most often implemented in software first.

Conclusion

Consumer electronics, multimedia, and telecommunication products that process audio, video, and data signals utilize DSP subsystems to perform the digital signal processing. Designing the best DSP subsystem for a product requires knowledge of the available software for each DSP in question. Strong DSP software companies can provide applications and tools to greatly accelerate your product to the market. Some companies also offer turn-key software packages that can be customized to a hardware platform of your choice (custom designed or a third-party card). Except in very high volume, simple products, software is the key to a product's DSP subsystem.

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