PC-Based Platforms Serve Up High-Speed Data Acquisition Systems

Now that PCs can sustain waveform recordings at up to 700 Mbytes/s, they can be used as platforms for developing advanced SIGINT, radar, NDT/ultrasound and medical imaging data recording systems.

by Tom Wagner and Anthony Hunt
Signatec

Historically, proprietary direct-to-disk waveform recorder systems were the only option available to deliver high-speed signal recording solutions if data loss could not be tolerated. There are clear performance benefits of the direct-to-storage recording systems that continue to provide important capabilities in signal recording.

Proprietary recording systems traditionally digitize analog signals and transfer the digitized data directly to a storage device. Yet, while direct-to-disk recording systems offer high-speed data transfers with few bottlenecks, raw data typically isn't as useful as data stored in a compatible file system, such as NTFS. For certain applications, this is a fair trade-off. However, a decided disadvantage exists, especially for applications that require recorded data to be sent to other systems.

By translating raw data into an OS-friendly file format, considerable efficiencies emerge. For example, if a recording system resides on a network and the recorder must be controlled by a client machine, compatible files provide the client immediate access to the data. If the files are incompatible, sharing data between the recording system and client requires significant custom software development for network-based applications that would otherwise come mostly for free with standard OS support.

Figure 1 Current PC chassis enable engineers to integrate many disk drives into a single system, such as this single-chassis, 700 Mbyte/s wideband signal recorder platform.

Additionally, proprietary recording solutions are less flexible and significantly more costly. Not only is the purchase price high, but next-generation storage technologies are not easily integrated. Instead, to achieve significant performance upgrades, entirely new recording systems must be developed, increasing cost.

Fortunately, given the latest technology advancements in PCs, a compelling argument emerges for developers of signal intelligence (SIGINT), radar, non-destructive testing (NDT)/ultrasound and medical imaging systems to employ as many COTS technologies as possible for their advanced systems.

PC-Based Recording Solutions Deliver High Performance

With ever-increasing performance features, current PC workstations and server-class computer systems can serve as affordable, real-time recording systems. By leveraging the latest COTS computer components, engineers can design best-of-class waveform digitizers to stream data continuously to disk storage

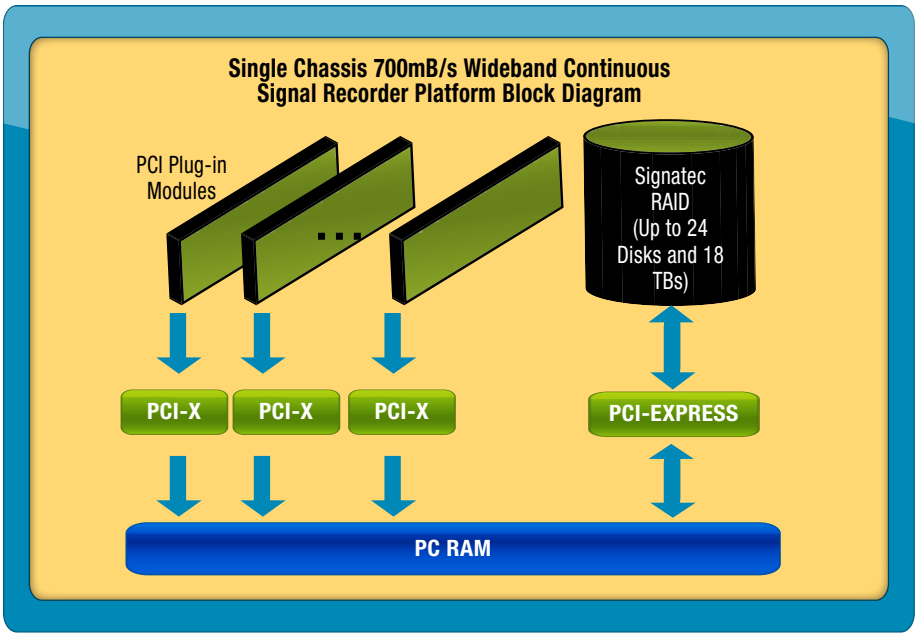

Figure 2 High-speed recording systems with up to 18 Terabytes of disk storage space can be built on PC-based platforms using the right design techniques.

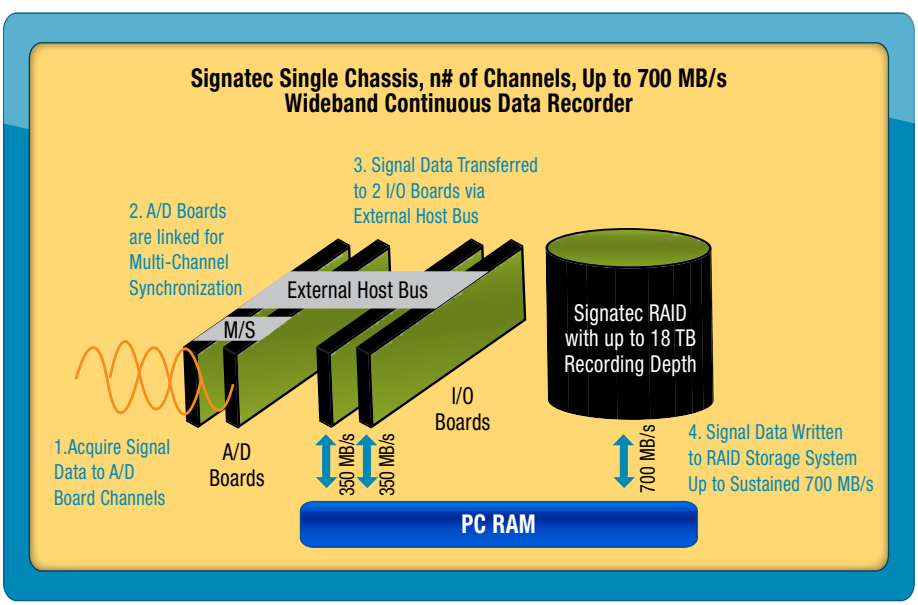

Figure 3 The Signatec DR700 multichannel, 700 Mbyte/s signal recorder system, can continuously record up to 700 Msamples/s of data through the PC to disk storage without any break in the analog record.

systems without any break in the analog record, and for a fraction of the cost of proprietary recording systems.

Today, high-performance PC systems deliver such a powerful, affordable platform for creating real-time solutions with exceptional performance features that strong consideration should be given before disregarding PC-based, high-speed recording solutions. To further support the PC as a quality alternative to proprietary systems, one may consider the additional benefit of significant peripheral features such as high-speed networking interfaces, USB ports and parallel/serial bus interfaces.

Since the latest motherboard and integrated RAID system options can form real-time, wideband signal data recording systems, highly optimized COTS solutions become an important scalable solution for system developers. Next-generation components can often be readily integrated into older PC-based systems, providing immediate performance upgrades with little capital expenditure.

Most importantly, if waveform digitizers are skillfully engineered, the increased PC performance provided by COTS computer upgrades can often result in entirely new advanced system capabilities for developers. As a net benefit to signal recording system developers, these significantly increased performance systems often come for free. The scalability and flexibility of COTS solutions creates an entirely new paradigm for project managers who must successfully deliver advanced solutions on time and on budget.

Architectural Overview

High-performance computer systems incorporate the latest in PC-based technology and utilize motherboards with multiple PCI, PCI-X and PCI Express bus interface options. These can be leveraged to create advanced signal technology products and maximize operational performance. Multiple PCI buses, with their own dedicated resources, ensure that the maximum transfer rate is achieved for multiple boards by reducing the number of devices competing for bandwidth, since PCI modules have their own high-speed path to the host PC system memory.

Additionally, current PC chassis enable engineers to integrate many disk drives into a single system, often eliminating the need for multiple systems, which lowers cost substantially (Figure 1). Developers can now integrate high-performance data acquisition, digital signal processing, signal generation and data recording boards all within a single unit to create a fully integrated, low-cost turnkey system solution.

Furthermore, these integrated disk storage systems are capable of sustaining the very high data rates required for demanding, real-time data recording applications. Since data transfer rates and storage capacities are scalable, sustained, extremely high transfer rates are possible, with storage capacities available up to 18 Terabytes, all within a single chassis solution (Figure 2).

Current chipsets such as Intel's 5000P support up to a 667 DDR II memory interface, 1,333 MHz frontside bus to the CPU and multicore processors. Additionally, these motherboards accommodate independent PCI/PCI-X/PCIe buses, allowing concurrent, high-bandwidth access to PC system memory.

The previous generation of server-class motherboards with Intel's E7520 chipsets only allowed PC motherboards to support a 400 MHz DDR II memory interface, 800 MHz front-side bus to the CPU and single-core processors. Compared to this previous generation of chipsets, the 5000P chipset has typical improvements of up to 4:1, according to published Intel benchmarks.

This serves as an excellent example of how a next-generation motherboard can create an entirely new product. The E7520 chipset formed the foundation for a 250 Mbyte/s continuous real-time signal recording system. By upgrading to the new 5000P chipset, new real-time recording systems can sustain 700 Mbyte/s continuous real-time recording rates, without the need to re-engineer board-level components.

The argument to go with COTS computer components is simply too strong. While the next significant signal recording performance upgrade always looms six months ahead, the cost of upgrading pales to insignificance when compared to purchasing next-generation proprietary systems.

Disk and RAID architectures are also a major concern. The specifications of virtually all RAID storage systems can be misleading in terms of actual sustainable transfer rates to the disks. In many cases, the only number specified is the peak "bandwidth" data rate for the bus type used. Actual sustained performance varies dramatically among various RAID manufacturers and components. However, high-performance COTS RAID systems can be leveraged to engineer quality, affordable storage solutions to achieve the highest sustained transfer rates possible.

RAID systems conform to various data storage and redundancy concepts, defined as levels. Although capable of operating at various RAID levels, in order to maximize performance a disk storage system specifically designed for operation at RAID Level 0 ensures no data redundancy. Such a design provides the maximum transfer rate performance possible and maximizes the amount of available storage space.

The option of employing COTS computer components to form the PC hardware requirements for achieving 700 Mbyte/s signal recording without a break in the analog record is a proven fact. However, COTS computer components will not achieve real-time results on their own. Well-designed, optimized data acquisition boards are the key to transforming non-real-time PCs into real-time, high-speed recording systems.

Transforming PCs into High-Speed Waveform Recording Systems

Since most contemporary operating systems—such as Windows or Linux—are not real-time environments, PCs are often overlooked as a real-time option. Yet, properly engineered subcomponent hardware and software can transform PC systems into effective real-time signal recording solutions. Such systems are capable of streaming data through the PC to disk in real time with no lost samples at ever-increasing sustained rates. The key lies in developing the proper buffering techniques.

Engineering waveform recording boards, designed with large memory buffers and a high-speed bus interface to withstand the non-real-time nature of PC systems, becomes the heart of the art. A sufficient buffer is essential to account for the periods when a PC system is busy handling other tasks, as well as a high-speed bus interface to offload that buffered data. With these design features, data acquisition boards will simultaneously acquire, buffer and transfer data to prevent a break in the analog record.

Considerable thought needs to go into buffering techniques. For example, if the data buffer is too small to handle host bus downtime, the buffer will overflow. Similarly, if the external bus interface is too slow, buffered data will not transfer off of the board in time. In either case, the net result is the same: a break in the analog record.

For many advanced SIGINT, radar, NDT/ultrasound and medical imaging applications, overflow conditions are disastrous. Fortunately, since memory is affordable, waveform digitizers should and can incorporate as much RAM as necessary to buffer the acquired signal data. In addition, current wideband buses, such as PCI-X or PCIe, deliver sufficient data throughputs between digitizer boards and host PC to sustain high data recording rates.

With the appropriate combination of COTS motherboard, RAID components, waveform digitizers and software solutions, high-speed turnkey signal recording systems are commercially available today.

For example, Signatec's DR700 signal recording system was created for developers of advanced SIGINT, radar, NDT/ultrasound and medical imaging applications. These systems can continuously record up to 700 Msamples/s of data through the PC to disk storage without any break in the analog record (Figure 3).

Multiple channels can be integrated within the system by utilizing waveform digitizer products in a master-slave configuration, allowing users to connect multiple A/D boards and create a synchronized, multichannel acquisition system. In master-slave operation, the master board drives the clock and trigger signals for the slave boards so that data on the slave boards align sample-for-sample with the data on the master board.

System subcomponents can provide numerous combinations of high-speed acquisitions, with accommodations for large-bandwidth and high-resolution applications, along with an extremely large memory capacity. For example, a subcomponent board with two 150 MHz,

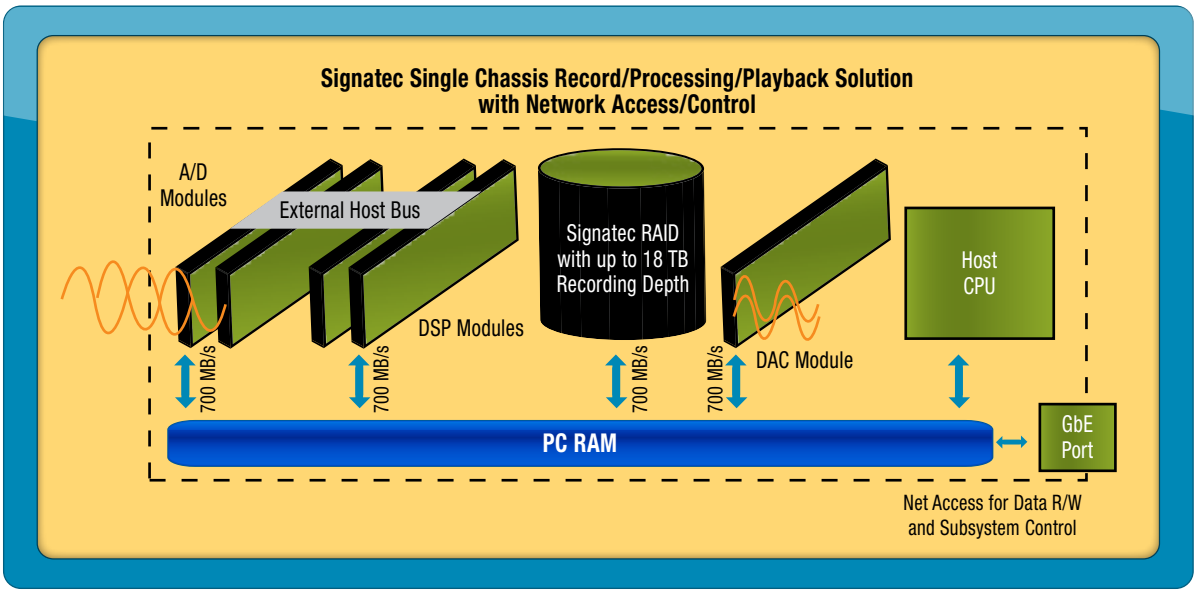

Figure 4 Fully-integrated, single-chassis data acquisition, recording, processing and playback solution with network access and control.

16-bit channels for a total data rate of 600 Mbytes/s creates an extremely high-speed, high-resolution recording solution.

Added Value: Integrated Flexible Recording, Processing and Playback Systems

The option to engineer high-speed interfaces on the PC's subcomponent boards, which operate externally to it, should not be discarded. These can be very effective for linking acquisition boards with other plug-in cards—such as processing accelerators—when the PC's resources are either insufficient or threatened by potentially being overly taxed. However, an external board interface does not replace the host bus, but augments it. An optimized application that uses the external interface for time-critical data movements can also use the PC host bus for less critical operations. Since both buses are in simultaneous operation, system throughput is maximized.

In addition to recording at high rates, signal data can also be processed at very high rates, effectively converting the PC into a signal acquisition, real-time processor and recorder solution. Since the platform provides the I/O for linking the A/D module to the CPU for processing, as well as the I/O for linking the CPU to the RAID for data storage, engineers need only focus on designing the appropriate acquisition module and software.

Furthermore, users wishing to play back their collected data for analysis can employ the same recording platform populated with playback modules to create a continuous signal playback solution based upon the same signal recording model. By adding D/A conversion modules with buffering techniques similar to those engineered on the A/D modules, digital data can be streamed direct from disk storage at the same high rates for playback as for recording.

With numerous COTS solutions available to SIGINT, radar, NDT/ultrasound and medical imaging system developers, PC systems can now sustain waveform recordings at up to 700 Mbytes/s. In addition, high-speed signal playback, real-time processing and network control capabilities can be integrated seamlessly into a single host system (Figure 4). Effectively, there has never been a better time to strongly consider PCs as the ideal platform for bringing the fastest, most flexible, scalable and affordable signal technology solution to market. ◢

Signatec
Newport Beach, CA.
(949) 729-1084.
[www.signatec.com].