FPGA Solutions for Ultrasound

Introduction

Ultrasound scanners are going through a rapid phase of evolution as integration makes it possible to use many channels in parallel for greater resolution and usability. Smaller ultrasound devices—even handheld—are being developed. Flash-based FPGAs provide the opportunity to take integration further and develop even more flexible and portable systems.

Ultrasound Systems

Historically, ultrasound systems weighed hundreds of pounds and were large and expensive. In the past it was more practical to bring the bedridden patient, bed and all, to the ultrasound machine rather than vice versa. Only in the case of the critically ill patients who could not be moved was the ultrasound system maneuvered, with difficulty, to the patient.

Over time, portable ultrasound technologies emerged, but achieving image quality on a par with the larger devices proved to be a challenge, as was achieving the battery life, high-power computing, and efficient memory access that these applications require. As a result, physicians now see ultrasound as a more cost effective and more mobile alternative to computed tomography (CT) and magnetic resonance imaging (MRI) scanners.

High-quality handheld systems enable routine bedside scanning. This has not only improved patient access to safe, noninvasive diagnostic medicine, but has also reduced the time and costs associated with such diagnostics.

Market Expectations

Although the global market for ultrasound imaging equipment has hovered around $5bn since 2008, according to InMedica, a return to growth is expected from 2011, with rapid increases in shipments forecast for the Asia Pacific region in particular.

High End Systems

In tandem with miniaturization, ultrasound machines have become more capable and have introduced more imaging modalities as well as sampling a higher number of channels for greater image fidelity. Higher end systems are incorporating more advanced 4D algorithms that allow clinicians and patients to see moving volumetric images in real-time. 4D imaging makes it easier for the clinician to diagnose problems much more quickly than with overlays of conventional 2D imagery that demand they line up images taken at different times by hand.

The ultrasound inputs themselves need conditioning and processing to ensure that the signal analysis software running on a DSP or host processor receives the best possible data. In multichannel and 4D ultrasound, it is vital that data from sensors is captured with minimal jitter to ensure that the signals are correctly correlated in time. At the same time, multichannel ultrasound relies on the accurate use of beamforming, using pulses fired at specific times to create the desired set of pulses relayed by the ultrasound transducer.

Microsemi Solutions for Ultrasound Systems

Although a microprocessor can use interrupt service routines to capture and store data from each of the inputs in turn, it takes many instruction cycles to achieve, which reduces the temporal accuracy. Microsemi's processor offload technology for analog I/O implemented in the SmartFusion™ family of integrated devices, for example, can overcome this problem. At the same time, it can reduce the loading on the host processor by massively reducing the number of interrupts it has to service, providing more time to run complex signal-processing algorithms.

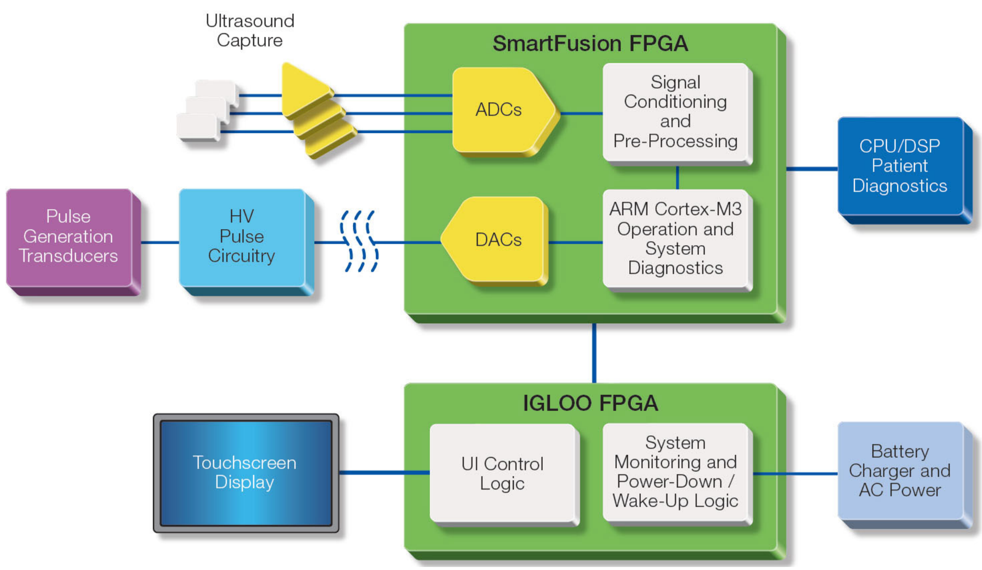

Figure 1 • **Block Diagram of an Ultrasound System**

The analog compute engine (ACE) is a small independent processor that offloads from the ARM® Cortex™-M3 on the FPGA the job of initializing and controlling the various analog I/O ports supported by the device. The ACE uses a sample sequencing engine (SSE) and a post-processing engine (PPE). The SSE captures data from the analog inputs, passing it to the PPE, which can perform functions such as low-pass filtering to remove noise, and transform the data into a format convenient for the processor. Devolving these functions into hardware ensures that vital data samples are not missed if the processor misses an interrupt deadline, maintaining the temporal correlation that is needed by multichannel ultrasound.

As LCDs and similar displays can consume as much as 50 per cent of an application's power budget, careful control over the display is vital. Careful design that puts the LCD and control logic into power-saving modes whenever possible can massively reduce battery drain. With its Flash*Freeze mode, the IGLOO® family of FPGAs provides ultra-low power modes that minimize leakage when the ultrasound device is not in use.

Optimized for I/O intensive operations, flash-based IGLOO devices cut dynamic power in half compared with competing SRAM-based FPGAs, ensuring less energy use when the ultrasound scanner's display is active. The high integration of the IGLOO device means that many of the system functions can be absorbed into one package, as small as 3x3 mm, helping to optimize size and weight as well as power.

Summary

Microsemi's FPGAs provide the perfect fit for ultrasound devices, from the smallest handheld devices to sophisticated multichannel machines.

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