FPGA expertise for signal processing in portable ultrasound devices

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As a vital means of clinical imaging diagnosis, ultrasound examination plays a key role in veterinary medicine. Anesthesia is not required so many diseases of the internal organs can be quickly detected, and the results of professional animal breeding checked. Portable analytical devices for real-time image display are less intrusive for both humans and animals.

Figure 1. Ibex EVO ultrasound device for vets and professional animal breeders

■ US company E.I. Medical Imaging is rapidly taking a lead in this market with its Ibex ultrasound devices for vets and professional animal breeders. These devices enable swift determination of the fertilization phase and can verify pregnancy at an early stage. In developing the Ibex devices, E.I. Medical relies on the FPGA expertise of NetModule. The latest generation - Ibex EVO - had to overcome a particular challenge with the interaction between the software, the Xilinx FPGA, the system CPU, data transmission using SerDes technology as well as the real-time processing of ultrasound signals all the way to the presentation of the imagery.

In addition to its system design expertise in realizing circuitry logic, NetModule applied its professional competence in the real-time processing of rapid image signals such as ultrasound using powerful FPGAs. At the heart of the Ibex ultrasound imagery unit is a signal processor realized in FPGA. This high-performance FPGA core provides an ideal platform for the exceptionally high signal-processing throughput required in order to realize basic functional elements.

These include the beam former for calculating the high-resolution ultrasound beams from numerous parallel receiver channels, the signal processing chain for filtering, envelope detection and signal enhancement, as well as the scan converter for converting polar or rectangular scan formats into a standard video-compatible format.

This Ibex EVO device generation, too, uses the largest chip from the most cost-effective Xilinx product line. This is important as the ultrasound scanners are destined for sale in a price-sensitive market. Whereas a Spartan3A DSP served as the core of the first generation, the Ibex EVO uses an FPGA from the Artix7 family, which enables much more powerful signal processing that provides images of unprecedented quality on a portable ultrasound device of this type.

Ultrasound technology calls for extensive and CPU-intensive signal processing, which means that the number of available DSP cells in the FPGA is key. A DSP cell contains a hardware multiplier and two adders. At the cycle frequency of 160 MHz applied here, this type of cell can perform 160 million multiplications and 320 million additions per second. However, the FPGA chip contains a large number of these cells: where the first generation consisting of the Ibex Lite and Ibex Pro products with the Spartan3A DSP chip (model 3400A) used 126 of these arithmetic units, the new 2nd generation Ibex EVO with the Artix7 (model 200T) features no less than 740 DSP arithmetic units. This enables a higher number of additions per second, accordingly. For the Ibex EVO ultrasound devices, this allowed the number of channels for sending and receiving to be increased from 16 to 64. As a result the display of ultrasound images benefits, while sharpness and contrast increase in line with the number of channels used. This, in turn, enables a larger display format in SVGA image quality.

The second hurdle was to realize the connection of the transducer to the FPGA. After all, 64 signal channels also require 64 analog-to-digital converters. In this case, NetModule opted for the relatively new SerDes technology that is capable of transmitting data at 3.2 GBit per connection. The system consists of a serializer/deserializer - for the serial transmission of parallel data. The parallel data to be transmitted is converted in the serializer into a serial data stream with a high bit rate. It is then transferred serially, and reconverted again in parallel in the deserializer for further processing. (Source: Wikipedia)

The system also features a function that sets it apart: the Ibex Evo scanners can be used to show the flow of blood in the body. This technology, known as Doppler Ultrasound and Colour Doppler, is based on the physical phenomenon of the Doppler effect: if sound

Figure 2. Ultrasonic device analysing the health of a horse leg

transmitters and receivers move towards or away from one another, runtime delays are created. This can be exploited in medicine to show movements of bodily fluids (e.g. blood). Movements towards the ultrasonic transmitter are usually overlaid in red, while movements away from it are overlaid in blue (-> Colour Doppler). *(Source: Wikipedia)*

This latest Ibex EVO generation is equipped with a sealed 8.4" (approximately. 21.33 cm) LED display and a backlit keyboard. The complete digital image is always clearly visible even in sunlight and shows unprecedented quality for such a portable and robust ultrasound device. The device displays all modes – B, B+M, PD and colour. The scanners are portable and can operate independently of the mains supply (battery operation). Weighing a mere 2.8 kg, these ultrasound devices are true lightweights that are ready for immediate use.

Their batteries supply power for more than 3 hours and can easily be replaced while the device is in use. Since animals are examined in their natural surroundings, the scanners must function in harsh environments, both in sunshine and rain as well as in dirty environments, and they must also be waterproof and easy to clean.

Thanks to DuraScan technology, they are not only shockproof and dustproof but also biologically safe. In other words, they pose no risk to the animals being examined. In addition to swift results and the high degree of precision, the devices impress with their cost efficiency and longevity (EVO converters have survived 1.2 million load cycles in use). Vets can check their results directly, thus saving valuable time. ■