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FRAUNHOFER-INSTITUT FÜR BIOMEDIZINISCHE TECHNIK IBMT

1 *MRI-tested DiPhAS platform.*
2 *Mainboard.*

ULTRASOUND BEAMFORMER PLATFORM - DiPhAS

System Description

In the last decades, ultrasound has become more important beyond medical diagnostics, in industrial applications, but also increasingly has established itself as an extremely powerful tool in sonar technologies. The image quality of an ultrasound device is extremely dependent on its beamforming properties. The use of multi-channel ultrasound platforms makes it possible to use modern methods such as plane wave imaging, dynamic focusing, steering and pulse coding to generate a corresponding acoustic beam.

The Digital Phased Array System *"DiPhAS"* developed in-house at the Fraunhofer IBMT has been specifically designed as a systemic research and development platform that can be adapted to a wide variety of requirements. The special feature of this ultrasound research hardware platform is the ability to control the entire beamforming and to access all data of the signal processing chain, from the RF signal of a single ultrasound element to the classical ultrasound B-scan, openly and flexibly. The modularity and application-specific possibilities of this highly innovative ultrasound beamformer are unique worldwide and are in demand in numerous areas of research and development.

System Characteristics

The system is based on a modular platform concept consisting of a mainboard, a power supply, an integrated PC and 16 application-specific frontend boards on which the actual transmit and receive circuits are located. Each frontend integrates up to 16 parallel channels.

The built-in transmit circuits are able to generate individual signals for each channel with a resolution of up to 2 ns. The output stages of the transmit pulse generators are designed to provide tri-state burst waveforms with adjustable amplitudes of up to +/-100V. The user has the ability to precisely adjust the center frequency, the number of burst signal cycles, and delays per channel to suit the characteristics of a defined sound beam.

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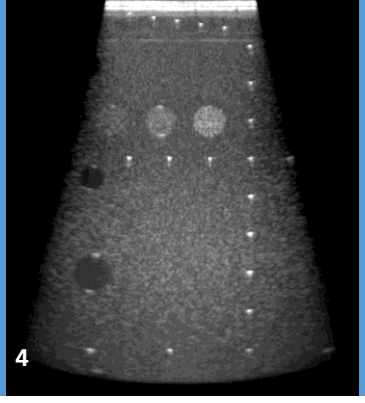

On the receiving side, the sensitive components are first protected from the high voltages of the transmitter by a limiter circuit. This is followed by low-noise pre-amplification, time gain control, filtering and digitization of the received signal. The system digitizes at sampling rates between 20 and 80 MSPS. The received data will be pre-processed in FPGAs and stored in DDR3 memories, without the need of transferring data to PC in between.

Signal processing and beamforming is completely done on parallel computing graphic processors (GPUs). The interface between beamformer and PC is realized by using PCIe providing typ. up to 12 Gbit/s of DMA transfer speed.

A specially developed power supply provides all the necessary operating voltages for the individual electronic components. The high transmission voltages are also generated by the use of switching pulsers on the power board.

The ultrasound system is integrated with a PC in an EMI-compatible housing. On request, the electronics can be shielded so that it can be operated in a magnetic field close to an MR tomograph.

3D Imaging Option

In 3D imaging with multi-element matrix array transducers, it is preferable to use transmit and receive electronics capable of addressing as many elements as possible simultaneously. Compared to the use of a multiplexer circuit, this has the advantage of generating more energy in the sound field on the one hand and on the other hand reduces the risk of increased motion artifacts.
It is possible to connect up to four DiPhAS to a single 1024-channel system. The specially developed synchronization circuit ensures that all systems work with exactly the same clock. A total of four PCIe interfaces transfer the data to a powerful PC, where further data processing and analysis takes place.

HIFU Option

In addition to classical imaging, ultrasound is also used for therapeutic purposes, especially in tumor therapy. High intensity ultrasound waves are bundled in order to heat and treat diseased tissue (HIFU). In order to generate high-intensity ultrasound waves, the multi-channel beamformer must be equipped with a power pulse output stage that makes it possible to provide high average transmission powers - up to 16 W per channel - in a frequency range from 50 kHz to 3 MHz over periods of several minutes. The power pulse generator provides tri-state signals with adjustable amplitudes of up to +/-100 V. It can be designed for up to 256 parallel channels and is fully controlled by the multi-channel beamformer.

Since the control of the power pulser was developed completely detached from the imaging area of the system, it is possible to operate imaging in addition to the HIFU application.

Apart from medical technology, the power pulse generator is already being used in completely different application areas, e.g. in the generation of 3D haptic feedback shapes.

Standard Specifications

Transmitter TX

Channels:	128 / 256
Transmit voltage:	Up to +/- 100 V (adjustable)
Transmit current:	Max. 4 A
Signals:	Tri-state burst signals (programmable in center frequency, number of cycles and delays for each channel)
Power per channel:	Max. 20W pulse power up to 32µs with max. pulse duty cycle, longer signals possible (up to 1ms tested) but pulse duty cycle has to be reduced
Resolution:	Typ. 2 ns
Signal length:	Max. 32 µs

Receiver RX

Channels:	128 / 256
Gain:	Max. 52 dB
TGC:	45 dB adjustable
A/D converter:	Typ. 80 MSPS / 12 bit
Local memory:	64 GByte

System

Frequency range:	300 kHz – 30 MHz
Power supply:	230 V AC
Power consumption:	Typ. 200 W (without PC)
Signal processing:	GPU based, PC integrated in same housing
Access to control parameters:	Fully user–programmable independent channels in transmit and receive, access to all available control parameters of the system
Access to raw RF data:	Yes
Data interface to PC:	PCIe 2.0 x8, DMA providing typ. 12 Gbit/s, using 1 PCIe cable
Transducer interface:	ITT Cannon DLM6-360 / ITT Cannon DL1-156
Trigger input:	4x included, 2x with optocoupler, synchronized to internal 1MHz clock, input voltage level can be specified by user (default: +5V)
Trigger output:	4x included, 2x with optocoupler, synchronized to system clock, +5V output voltage level
Interconnection of multiple systems:	Yes, up to 4 systems, 1024 channels addressable
Case:	Approx. dimensions: 350 x 450 x 440 mm, EMI shielded MRI tested
Weight:	Approx. 20 kg

3 *Mainboard including TX / RX boards.*

4 *Ultrasound phantom measurement.*