Small, Flexible and Advanced Phased Array Module for Customizing NDT Applications

Gavin Dao[1], William Lv[2]

[1]*Advanced OEM Solutions, Cincinnati, USA*

[2]*Advanced OEM Solutions, Shanghai, China*

Gavin.Dao@aos-ndt.com - William@aos-ndt.com

Abstract: Having a small, advanced and open platform phased array (PA) ultrasonic module provides new technological opportunities for both industrial and research applications. Industrial applications can benefit by creating seamless solutions that fit their particular need or niche. A smaller form factor advanced PA module allows mounting the instrument on a scanner or robotic arm, thus shortening the transducer cable, which provides better signal quality, better integration, avoids cable failures and reduces cost. Researchers require instrumentation that allows access to low-level parameters and raw data from the acquisition unit and the freedom to control and interface to instrumentation with their choice software language. However, key characteristics are essential such as a complete phased array feature set, excellent signal-to-noise ratio, fast data throughput, ruggedness, compact form factor and cost effectiveness.

Keywords: Non Destructive Testing; Phased Array; Ultrasound;

1 Introduction

As technology improves or manufacturing volume increases, Non-Destructive Testing (NDT) continues to be challenged by new applications and the growing need to inspect faster and more accurately. NDT applications are difficult to standardize due to the various industry needs, materials and part geometry. A large portion of the inspection system is the software driving the acquisition, analysis and automation. It would be difficult to have one locked down software application capable of managing all possible NDT applications. There is a need to be able to customize the software to fit the need of the NDT application.

2 OEMPA

OEMPA, pronounced by reading the letters O-E-M-P-A, is based on an OEM (Original Equipment Manufacturer) concept, and more specifically an OEM Phased Array Module that industrial users (e.g. Systems Integrators or NDT Equipment Manufacturers) can customize or create a solution to fit the exact application that is being targeted. (2) Naturally, the OEM concept fits well with the needs of Researchers that require an open and advanced data acquisition unit with Phased array features.

3 Phased Array Ultrasonic Acquisition

OEMPA is a PC-based phased array ultrasonic acquisition module with the following configurations: 16/16, 32/32, 16/128, 32/128, 64/64, and 128/128.

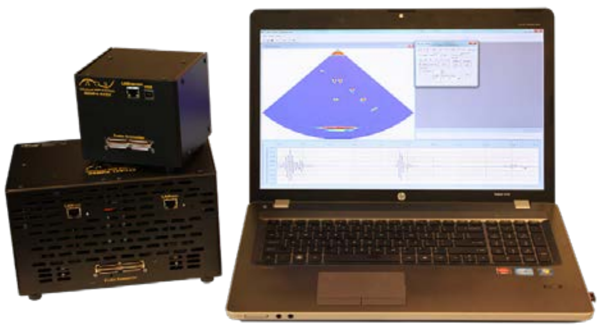

Figure 1. OEMPA 128/128 and OEMPA 64/64 with a Data Acquisition Notebook PC

These options provide an integrator the ability to cover more than one application without over-spending on the number of channels. Integrators can invest on a one-time software interfacing period and be able to easily plug-and-play a different hardware configuration to meet a different application.

There are many advantages to having a PC based scalable hardware platform. In this type of setup the Phased Array Acquisition unit sends digitized acquisition data to the PC via an Ethernet connection using the TCP/IP protocol. Ethernet is an easy way to interface a device with a tablet, laptop or desktop PC and also provides a robust and flexible means for remote control from almost anywhere.

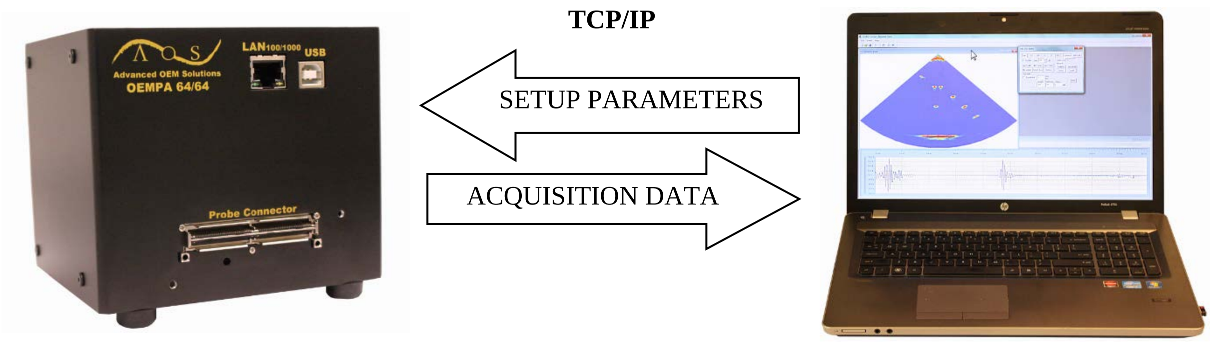

Figure 2. Data transfer via TCPIP

4 OEM Concept

OEMPA can be rebranded and integrated into an end-solution, whether it is a dedicated portable device for a particular niche inspection or large scale automated inspection system. NDT experts that now have the opportunity to offer a solution to their local market that is unique and an improvement based on their experience and know-how. The actual electronic modules as seen below can be provided so that OEMPA can be placed in a unique enclosure more suited for the application. The board on the top houses the pulsing analog circuitry, each of the four boards in the middle contain 16 parallel receive channel and the bottom board manages the data communication and some of the signal processing. This type of board stack creates a complete 64 parallel pulse/receive phased array module.

Figure 3. Bare OEMPA 64/64 Module

5 Small Size for Automation

The form factor plays an important role in integration. The small size allows one to place the acquisition unit closer to the transducer. Traditionally, advanced phased array acquisition units have been large in form factor due to the high channel count. Depending on the application (e.g. tank crawlers, girth weld inspection, sub-sea ROVs… etc.) umbilical cables are in the range of tens of meters long. Not only is the length an issue, but the cables can get thick due to the high channel count of phased array. The reliability of the constant movement and flexing of the cable also becomes an issue causing spares to be needed. As an example, Genesis Systems Group has been able to benefit by mounting an OEMPA 64/64 directly on the robot arm. **[3]**

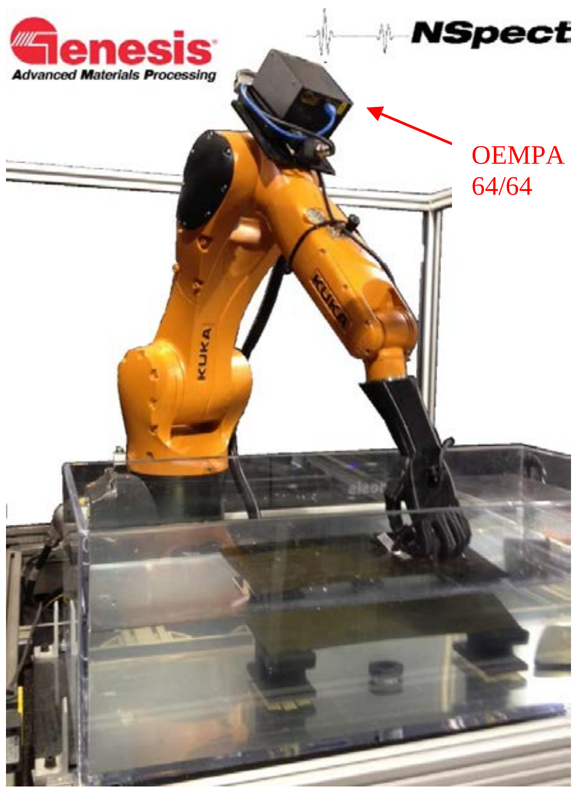

Figure 4. OEMPA mounted on robotic scanning arm

6 Hardware Internals

OEMPA includes many advanced features allowing it to be integrated into automated systems yet still maintain the small form factor, low power, and cost effectiveness. Some features worth mentioning are extremely low noise per channel, Dynamic Depth Focusing (DDF), Distance Amplitude Correction (DAC), up to 2048 cycles and more in some special cases, up to 20kHz Pulse Repetition Frequency (PRF), gates, filtering, and interface echo-tracking. OEMPA has the flexibility to easily create multiple groups of focal laws. This is useful in the scenario of running multiple scans, for example linear scans

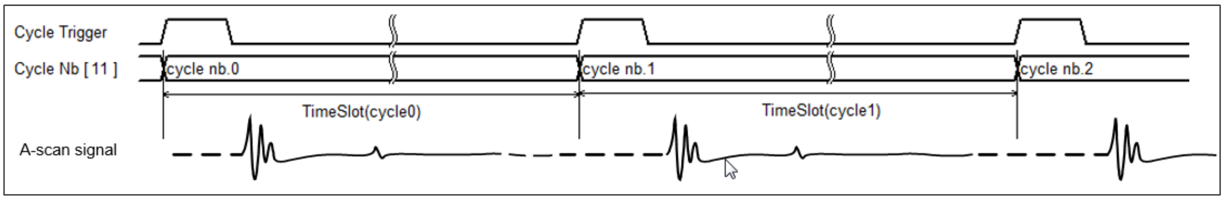

Figure 5. Visualization of Timeslot

at different angles and to be able to visualize this on multiple B-scan views coming from the same probe. Another scenario could be in the case of driving more than one probe from one OEMPA module using a probe splitter. As seen in the diagram below, a cycle is the identifier of a grouping of parameters for one particular focal law within a Time Slot and the corresponding acquired A-scan. From the perspective of the hardware it is sequencing through cycles, and the software application would be free to assign the data to the desired grouping when creating a B-scan visualization window.

7 Pulse Repetition Frequency (PRF)

It's also important to note that from the hardware perspective it is useful to think in terms of the Time Slot, because thinking in terms of PRF assumes the same Time Slot for every cycle. However, in OEMPA, each Cycle can have its own independent Time Slot value. See Figure 5 for the diagram of internal timing of a sequence of cycles. Notice that when the cycle trigger is high this is when the beamformer and other cycle dependent processes get updated with new parameter values. As soon as the update is done the pulse fires on a new cycle that corresponds to a new A-scan.

$$PRF = \frac{1}{TimeSlot} \quad (1)$$

8 Data Throughput

It's important to understand the concept of throughput in knowing the trade-off of PRF and how many points would be allowed in an A-scan when transferring A-scans from the instrument to the PC. As an example, assume each data point in an A-scan is 8-bits and that 100MHz sampling is used translating into a spacing of 10ns between each point. Let N represent the number of points in an A-scan. The range is defined as length of A-scan in a time based scale. This provides the following equation:

$$\text{Throughput} = N \times PRF \quad (2)$$

The number of points in an A-scan can be determined by:

$$N = \frac{Range}{10ns} \quad (3)$$

OEMPA also includes compression and decimation algorithms in the hardware that can help with minimizing the amount of data collected. It also helps if longer acquisition ranges are needed, while keeping a desired PRF without going over the throughput limitation.

8 Conclusions

The future direction of OEMPA will be increasing channel count while maintaining the concept of ruggedness, small form factor, high data throughput and enough advanced features to meet realistic application needs. Systems Integrators, NDT Equipment manufacturers and Researchers can stand to benefit from an open platform device that allows full control and customization.

References

[1] G. Dao and R. Ginzel, "New customizable phased array UT instrument opens door for furthering research and better industrial implementation," AIP Conf. Proc., vol. 1581, pp. 164, 2014.
[2] S. Gleeson, G. Dao, and J. K. Na, "In-situ weld quality inspection with matrix phased array (MPA) ultrasonic technology," AIP Conf. Proc., vol. 1581, Issue 1, pp. 95-99, 2014.
[3] Moon, W., "Improving NDI Productivity via Standardized Robotic Platforms," Proceedings of the SAMPE 2013 Conference, May 6-9, Long Beach, CA, 2013.