# Diagnostic Sonar Acquires and Processes Ultrasonic Phased Array Image Data with NI LabVIEW and PXI

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**Industry:**
Aerospace/Avionics, Imaging Equipment

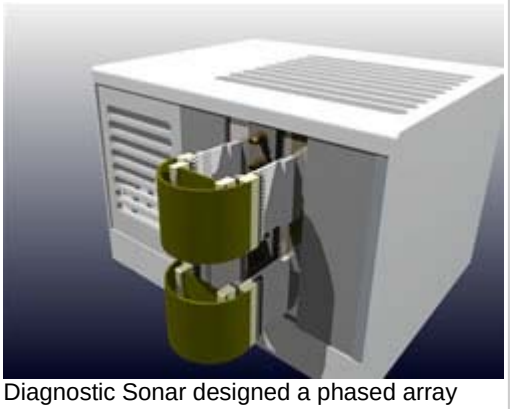
**Product:**
LabVIEW, LabVIEW FPGA, Oscilloscopes/Digitizers, PXI/CompactPCI, Vision

**The Challenge:**
Creating a scalable, low-cost system for rapid acquisition of ultrasonic phased array echo signals for advanced non-destructive evaluation.

**The Solution:**
Using National Instruments PXI controllers and chassis, multichannel high-speed digitizers, and reconfigurable I/O FPGA real-time controllers with National Instruments LabVIEW software to design a scalable acquisition system with tight timing and synchronization to perform phased array data acquisition for real-time ultrasonic imaging.

**Background**

Ultrasonic phased arrays have been used for many years for medical imaging, but until recently they have enjoyed limited success in non-destructive evaluation (NDE) due to cost and complexity. Diagnostic Sonar Ltd. has been using arrays for real-time imaging in aerospace NDE for three decades. This background has allowed us to pioneer a major new capability – termed full raw data (FRD) collection and processing – that offers significant benefits to the customer but imposes new challenges for data acquisition hardware and software.



Diagnostic Sonar designed a phased array data acquisition system for real-time ultrasonic imaging using NI LabVIEW software and PXI hardware.

Conventional pulse-echo ultrasound array imaging involves phased excitation of a group of elements from the ultrasonic array, with the differential delays between elements matching the differing propagation paths to generate a beam with specific focus and direction. The analogous reception process involves a recombination of the signals from a similar group of elements after appropriate differential delays have been inserted. These delays can be varied with time so that the receive focus tracks the transmit pulse, a process termed dynamic focusing. The image is composed of a sequence of beams scanned through the area of interest. The user perceives the performance to be real-time if frame rates exceed 15 Hz. However, area coverage requires significantly greater data rates, with 100 Hz rates routinely achieved.

In contrast, the FRD approach collects pulse-echo data from all transmit and receive element combinations and generates the resulting image by post-processing, permitting dynamic focus on transmit as well as receive for optimum resolution. This new technique also offers several unique processing possibilities, such as non-linear beam-forming and backscatter analysis.

**Previous System Limitations**

Our previous imaging system, “FlawInspecta,” is PCI-based and uses NI image acquisition cards with LabVIEW to acquire the non-standard video format of the ultrasound image data. We chose LabVIEW because it fulfilled our primary requirements – rapid development of simple but powerful user-interfaces, easy control of both off-the-shelf and custom hardware, and real-time image acquisition and processing offered by the NI Vision Development Module. This hardware and software combination was well-suited to the “conventional” real-time pulse-echo imaging application. However, the imaging card’s single channel limits the FRD area coverage rate. The only solution was parallel acquisition, but multiple imaging cards for parallel acquisition was cost-prohibitive.

**The NI System Solution**

The solution was to migrate to the new National Instruments PXI-5105 multichannel digitizer/PC-based oscilloscope, which is flexible enough to handle the image format we need and offer a simple software upgrade path. Each NI PXI-5105 acquires eight channels, allowing a single module to replace eight individual image acquisition cards and offering a major cost and size reduction. We can implement a 32-channel acquisition system with just four modules. The PXI-5105 also offers a performance increase, with 12-bit resolution at 60 MSps compared to our previous system’s 10-bit resolution at 40 MSps.

It is essential that all the acquisition cards are tightly synchronized, so we use a National Instruments PXI-7830R in the star trigger slot for the critical timing and control functions previously implemented in customized FPGAs.

With eight channels per module, high-resolution sampling (in amplitude and time), multirecord format, and a standardized driver interface for LabVIEW, the flexibility and modularity of the PXI-5105 provide a rugged system with virtually unlimited channel capability so that we can easily configure systems to match customers’ performance requirements and budgets.

**Challenges**

The FRD approach introduces two major challenges. The first is the order of magnitude increase in data, which could overwhelm the bus transfer capability. The onboard memory of the PXI-5105 provides a buffer so that the transfer constraint is limited by the average rate rather than peak rate. In the event that we exceed this rate when performing very rapid acquisition over a small area, the onboard memory is sufficient to hold all the data for transfer once the acquisition is over. The second challenge is the need to reconstruct the data into an image during acquisition. We found the speed of the NI Vision Development Module sufficient to perform this basic imaging on the fly.

**Summary**

NI hardware and NI LabVIEW software had already proved their worth in the current range of Diagnostic Sonar “FlawInspecta” ultrasound phased array imagers for non-destructive evaluation. Our new FRD acquisition approach offers many benefits to the customer, but the existing single-channel configuration would result in a significant drop in area coverage rate. We needed multiple acquisition channels, but the additional cost and size of multiple single-channel cards was not feasible. The PXI-5105 offered a solution that is scalable to customer requirements and has a multirecord capability that provides a simple software migration path.

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