LATEST HANDHELD ULTRASOUND CAMERA DEVELOPMENTS FOR INDUSTRIAL PARTS

R. Lasser, M. Lasser, J. Gurney, J. Kula, D. Rich, Imperium, Inc., Silver Spring, MD USA

Abstract: Ultrasound is arguably the most effective nondestructive testing method for the inspection of subsurface faults. However, hand scanning of parts is subject to inspector error and fatigue and automated point-by-point is extremely time consuming. We are reporting on the results of the use of a novel handheld camera for the rapid inspection of parts. This camera technology can be used for a variety of materials of different sizes and geometries. Using this system, subsurface corrosion, delaminations, voids, cracks and other faults in aging aircraft can be seen with high resolution and quantified immediately. This technique results in scans that can be done several times faster than conventional point-by-point or hand scanning. A non-specialized technician can easily understand the resulting imagery. Each frame, presented at TV rates, presents a C-scan image over an area. A handheld probe is placed against the target under study and a real time subsurface image appears on a display. The ultrasound system is lens-based and utilizes a two-dimensional imaging 120x120 element array. The array is similar to arrays used in standard video camcorders. However, the new imaging array is sensitive to ultrasound, not light. We will present recent data from the new handheld camera system on composites and metals.

Introduction: We are reporting on the latest developments of a real time ultrasound camera system. The basis for the system is a novel patented two-dimensional imaging system that creates real-time, high-resolution images of subsurface structures. Imperium has developed and patented a hybrid microelectronic array that is capable of generating ultrasound images with standard video presentation at video rates. The system can be operated to detect ultrasound energy received in either a through-transmission or pulse-echo modes as shown in the block diagrams in Figure 1.

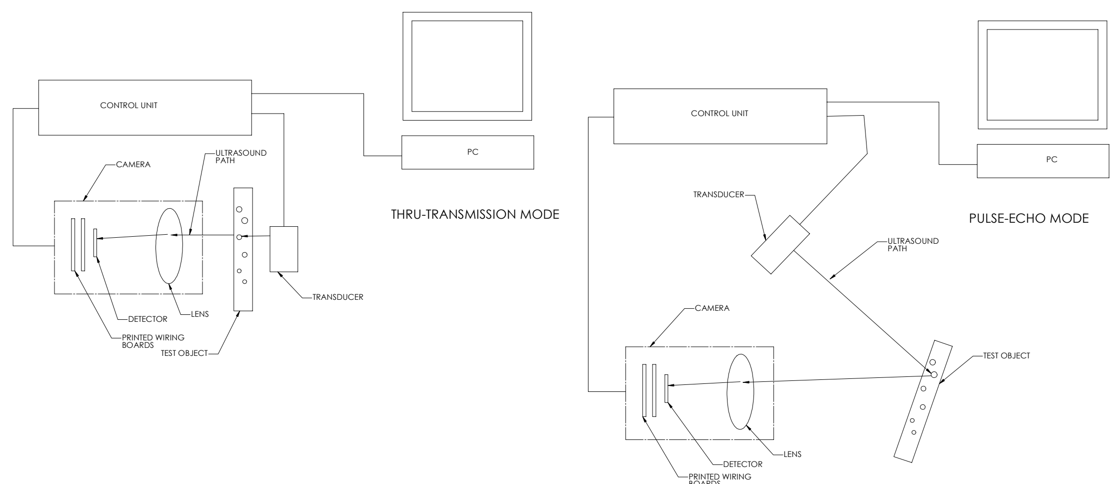


Figure 1: Functional Block Diagram

The system operates by exciting a large area unfocused ultrasound transducer (used only as a source) that generates a collimated plane wave. The resultant pressure wave strikes the target and is scattered. An acoustic lens collects the scattered energy and focuses it onto an ultrasound sensitive detector array. As shown in Figure 1, the process can be used in either the through transmission or pulse echo modes. With some camera designs, the face of the camera is placed in intimate contact with the test object by means of a special acoustic coupling gel or compliant pads or membranes. The camera housing is water filled.

The through transmission mode is straightforward and may be thought of as illuminating the test object with a "flashlight" of ultrasound. In pulse echo mode, the transducer ultrasound energy is scattered off of the test object. Imperium has designed and built cameras of both modes. For developmental work, it is preferable to work with a water tank that permits a great deal of flexibility to position the elements of the system easily in a variety of configurations in order to design the optimum configuration for the objects being measured.

The detector array is made up of two components, a custom Read Out Integrated Circuit (ROIC) and a piezoelectric material that is deposited onto the ROIC. The array is 12 mm on a side made up of 120 x 120 pixel elements (14,400) with 100 micron center-to-center spacing. The energy that strikes the piezoelectric material creates voltages that are read out by the multiplexer, similar in operation to a standard video CCD imaging array. A sketch of the array is shown in Figure 2. Note that there is an ultrasound sensitive piezoelectric layer deposited onto the chip. A completed array is shown in Figure 3. The array is responsive over a wide range of ultrasound frequencies, although most imaging is done between 1 MHz and 10 MHz.

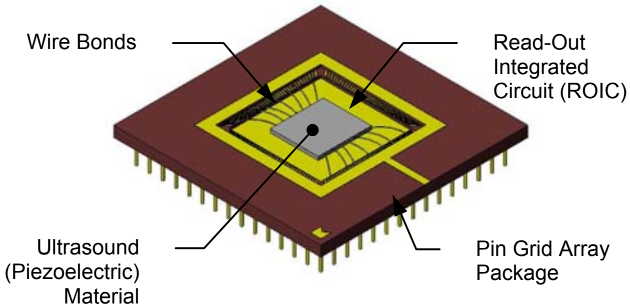


Figure 2. Array Schematic

The use of a lens provides a simple, inexpensive alternative to complex beam forming often employed in ultrasound imaging. The user simply focuses by adjusting the lens while looking at the image on a monitor. Furthermore, it provides a means to trade off resolution and area coverage, or zoom in and out. Currently, Imperium uses a 1 – 2 inch Field of View (FOV) in its production model systems and is experimenting with a 3 inch FOV for next generation models.

Results: Images from the ultrasound camera taken in 1/30 second are shown below.

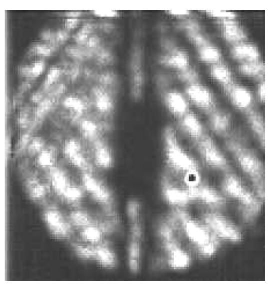
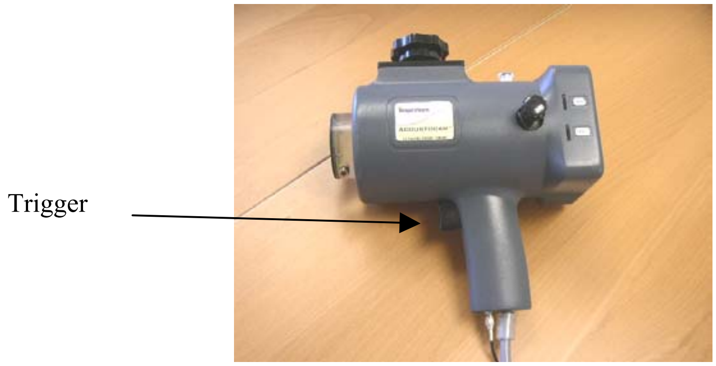


Figure 3: Through transmission image of radius with defect in center

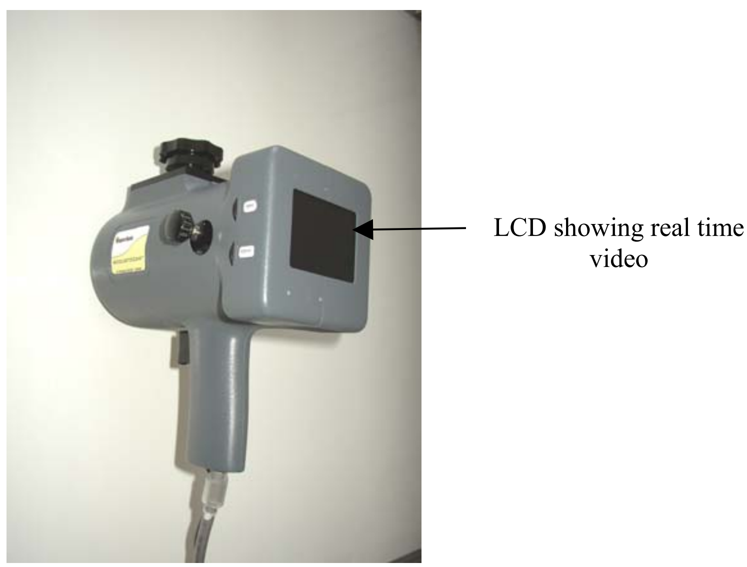
Figure 4: Pulse Echo Image of quarter

Imperium has done further development work in the handheld area through the development of a prototype design that is intended to employ the latest generation detector. This water filled prototype is shown in Figure 5 and incorporates a built-in 3.5” LCD display directly on the back of the unit for viewing of the images.



a. Side view of unit. Note trigger for taking snapshots of regions of interest

b. Front of unit. Note pliable membrane for coupling



c. Back of handheld unit. Note LCD with brightness and contrast controls

Figure 5: New Handheld Ultrasound Camera for rapid inspection of composites

Discussion: The use of the ultrasound camera provides a significant increase in productivity without sacrificing data quality. As an example, if an inspection is performed of a 10-foot by 10-foot component, with a minimum spatial resolution of 0.5-mm (21 mils) and a scanning rate of 12 inches per second, the difference in scanning time is as follows:

Current C-scan	Real-Time C-scan
100 (ft) ^{2}	*100 (ft)* ^{2}
6096 passes	*48 passes*
16.9 hours	***8 minutes***

Conclusions: Real-time, low cost C-scan technology offers an exciting next generation of ultrasound imaging. The use of semiconductor technology, and standard "optical" techniques such as lenses to create real time imagery means that commercial systems can be delivered at costs less than or equal to today's slower C-scan systems. For the hand held device, no formal training or certification would be required to observe subsurface faults. For in-service inspections, this technique can be used to quickly quantify very small defects.

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