DolphiCam™ 1.2 Technical Paper

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1 Introduction

This document describes version 1.2 of the DolphiCam™ acoustic camera. DolphiCam™ is a hand-held real-time imaging ultrasound camera with a dry-coupling front surface which enable inspection of, in particular, carbon fiber reinforced plastics (CFRP) without any liquid couplants.[1] DolphiCam™ can deliver 2 or 4 ultrasound images per second.

2 System Overview

Figure 1 shows an overview of the DolphiCam™. The transmit/receive control and on-camera signal processing is performed by a field-programmable gate array (FPGA). Version 1.2 of the DolphiCam™ has 8 different predefined pulses which drives the 2D

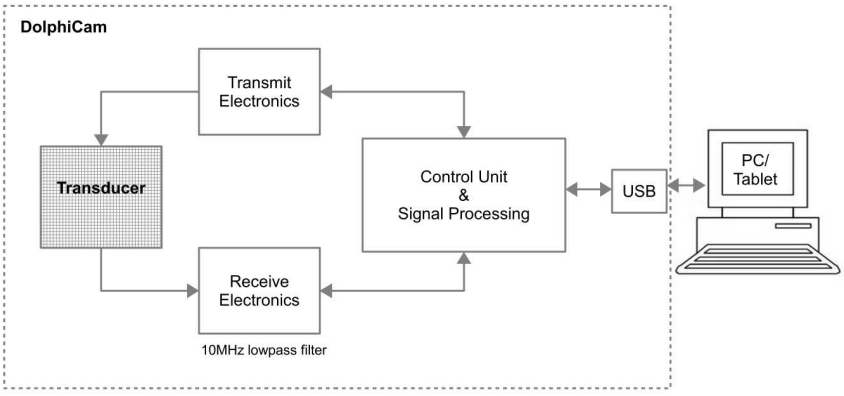


Figure 1: DolphiCam™ system overview.

transducer array using a high voltage driver. The received signals are first amplified and then filtered by an analog anti-aliasing filter with a cut-off frequency at 10 MHz. Second, after digitization, the acquired data are processed using the FPGA to increase the SNR

[1] The DolphiCam™ is build according to IP54 and can be used with liquid couplants, such as ultrasound gel or water, if desired.

and time-resolution. The system also have a user controlled averaging to improve the SNR further (2 or 4 averages). Finally, the FPGA performs basic feature extraction on the signal (amplitude and time) and sends data to the camera host. The software on the camera host controls settings on the camera and present images, such as

- envelope A-scans,
- X- and Y-directional envelope B-scans,
- amplitude and time-of-flight C-scans.

These images are presented as live video on the display device.

3 Transducer Specification

The transducer consists of a piezoelectric two dimensional 124×124 element array (15376 elements) which is illustrated in Figure 2). When a high voltage pulse is applied to a

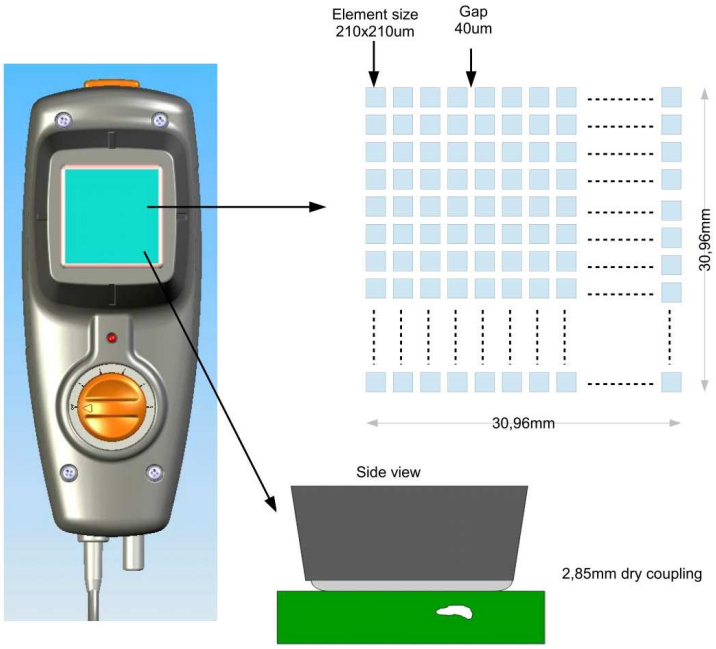


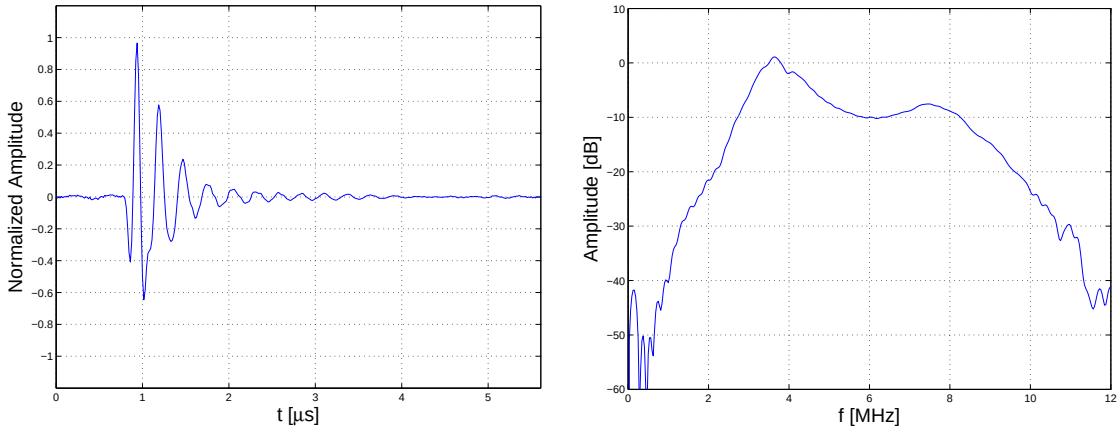
Figure 2: Illustration of the DolphiCam^{TM} transducer.

transducer element in the array, an acoustic wave is generated which travels through a 2.85 mm (dry) coupling pad and into the material under inspection. The reflected waves are then picked up by the same element in the array which then converts the mechanical energy to electrical signals. The geometry for the for the array is also presented in Table 1.

Number of transducer elements	$124 \times 124 = 15376$
Element size	210×210 [μm]
Element spacing	40 [μm]
Transducer width/length center-to-center	30.71 [mm]
Transducer width/length edge-to-edge	30.96 [mm]
Dry coupling thickness	2.85 [mm]
Dry coupling speed of sound	$\approx$ 960 [m/s] @ 20 [°C]

Table 1: DolphiCam^{TM} specs.

The transducer-to-air impulse and frequency responses of the transducer is shown in Figure 3.



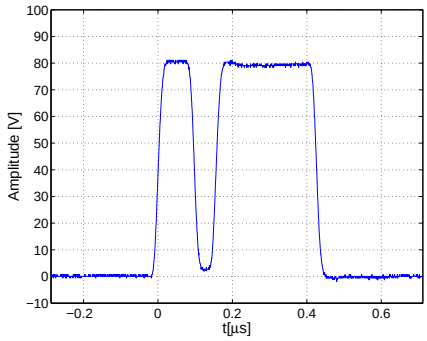
(a) Impulse response. (b) Frequency response.

Figure 3: Impulse and frequency response of the DolphiCam^{TM} 1.2 transducer measured using transducer-to-air data.

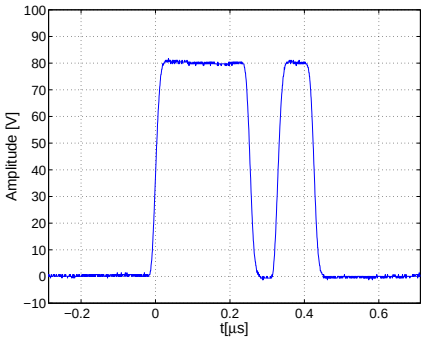
4 Pulses

The input transmit pulses are shown in Figure 4; the rise- and fall-time is $\approx$ 18 [ns].[2] Note that Pulse 1 is similar to pulse 2,pulse 5 to pulse 6, and pulse 7 to pulse 8, respectively; these pulses are kept in DolphiCam^{TM} 1.2 for compatibility with earlier releases of the system. The corresponding spectra of the input pulses are shown in Figure 5.

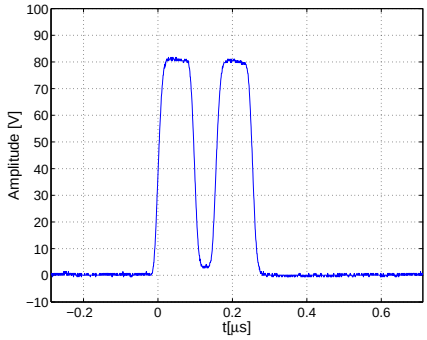
[2]The data were acquired with an Agilent MSO-X 4052A digital oscilloscope using an Agilent N2894A (700 MHz) probe.



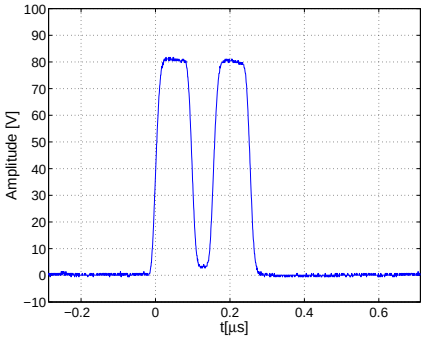
(a) Pulse 1.



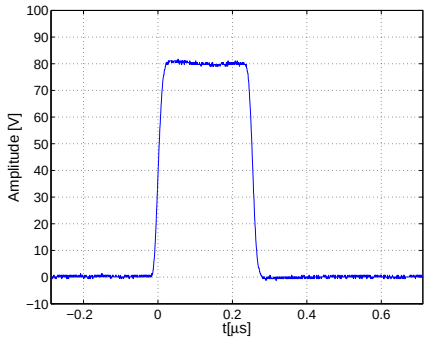
(b) Pulse 2.



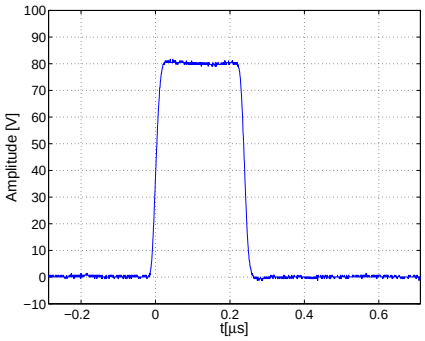
(c) Pulse 3.



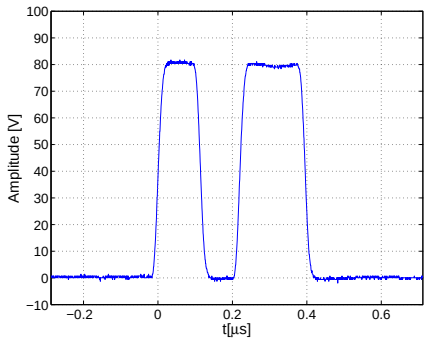
(d) Pulse 4.



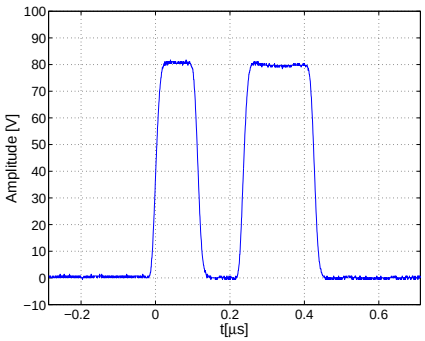
(e) Pulse 5.



(f) Pulse 6.

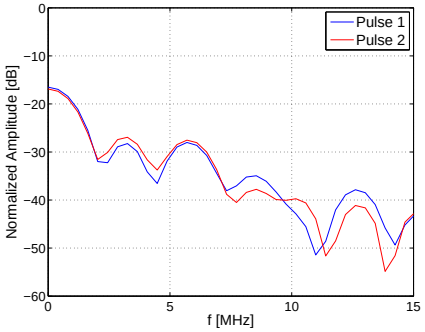


(g) Pulse 7.

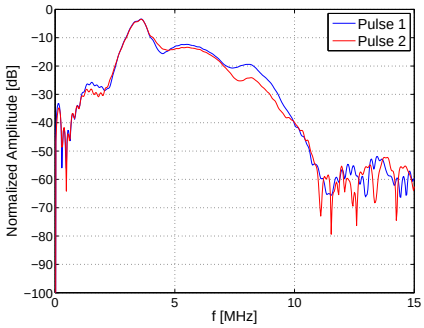


(h) Pulse 8.

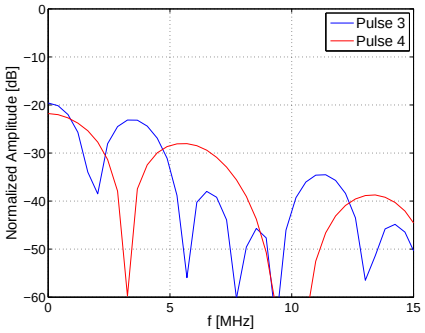
Figure 4: The input pulses for DolphiCam™ 1.2.



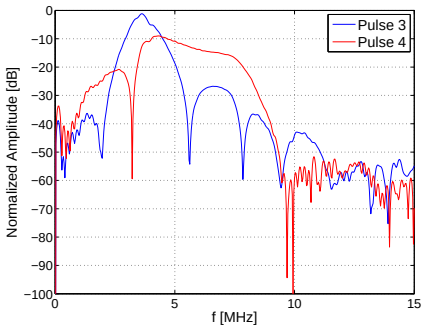
(a) Pulse 1 and 2.



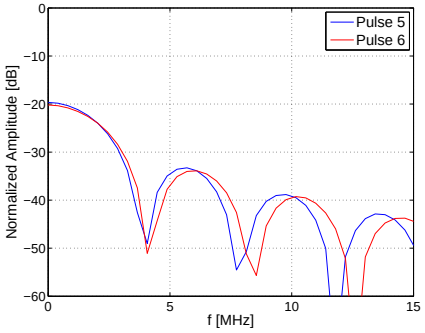
(b) Pulse 1 and 2 air responses.



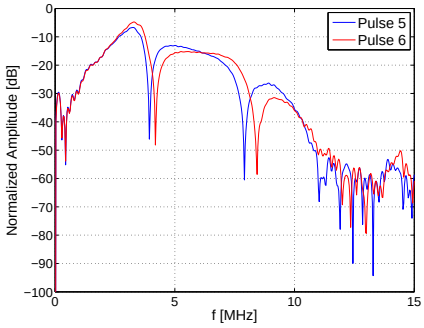
(c) Pulse 3 and 4.



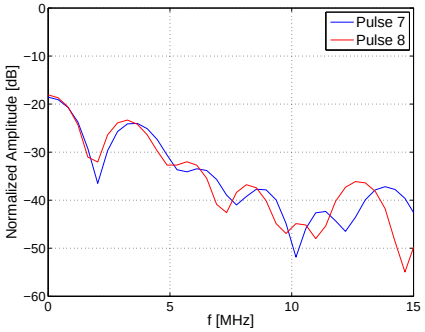
(d) Pulse 3 and 4 air responses.



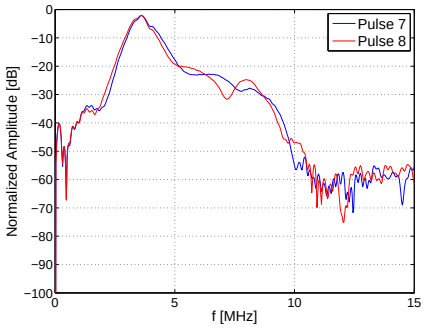
(e) Pulse 5 and 6.



(f) Pulse 5 and 6 air responses.



(g) Pulse 7 and 8.



(h) Pulse 7 and 8 air responses.

Figure 5: Spectra of the DolphiCam™ input pulses and the corresponding transducer-to-air frequency responses.