88. Direction Detection by acoustic and optic sensor data acquisition Draft 1.2

UFO-Doctor, Febr. 21th, 2015

1. Introduction (see also former Report 86!)

Direction finding at ideal conditions is an easy job!

You need a silent, dark room with anechoic and IR-absorbing walls and good sensors, that's all!

However, the real world is different:

A: Acoustic Problems:

- Reflections by obstacles
- Reverberation (collection of reflected sounds, lasting >1sec in large rooms)
- Air turbulence (Mic should be moved slowly only)
- Inhomogeneous temperature within the two acoustic paths
- Doppler effect by fast displacement of source or receiver
- Sound phase impurity (especially with omnidirectional Sound Source)
- Ambient noise with interfering ultrasonic signals.

B: IR-Optic Problems:

- Sunlight saturates standard IR-sensors
- IR-intensity must be above ambient IR-Level
- IR-reflections may disturb the optical path

2. Preliminary experimental result in the real world:

A: Acoustic Experiments at 40kHz with sophistic data acquisition:

- Method: Adaptive Trigger Level for catching the first peak, masking echo signals
- Good direction date within the angle range of +/-30 Degree, 0.5 to 12 Meters
- Difficulties with recognizing the valid angle range outside +/- 45 Degree

B. Optical Experiments outside at full sunshine:

- Method: Transmitter IR 940 nm, 1Watt, Receiver with 940nm interference filters
- Good, but nonlinear direction signal.

3. Proposal Concept

A combination of acoustic/optic sensors with data processing should be investigated.
Stationary transmitter with:
- Omnidirectional 40kHz US-Speaker and Omnidirectional 940nm IR light tour

Slowly rotating receiver with:
- 2 Mics 40kHz, Ear distance < 6mm, 2 shadowed IR-Diodes 940nm with interference filters
- Real time data processing (US: adaptive trigger level, IR : Intensity threshold

4. Proposal Data Processing

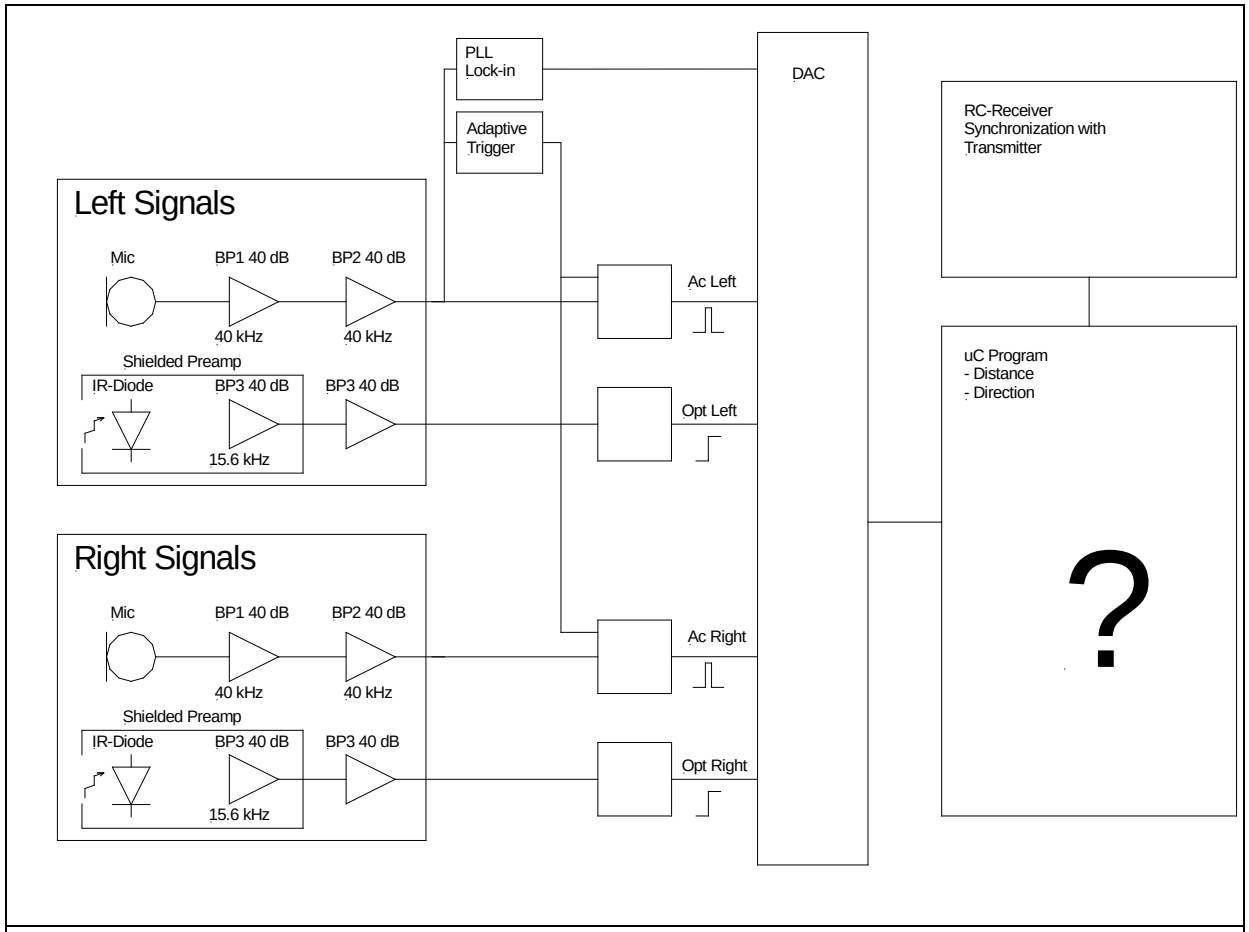


Fig. 1: Proposal for Data Processing

Desired Specifications:
- Fail safe direction detection, also in small rooms with US and IR reflecting walls
- Measuring range minimum +/- 25 degree, accuracy +/- 5 degree
- Distinct lock-in when the receiver is rotated
- Fail safe distance detection, also in small rooms with US and IR reflecting walls
- Measuring range minimum 0.1 to 20 meters, accuracy +/- 0.05 meters distances < 1 meter

5. Proposal Sensor Set-up

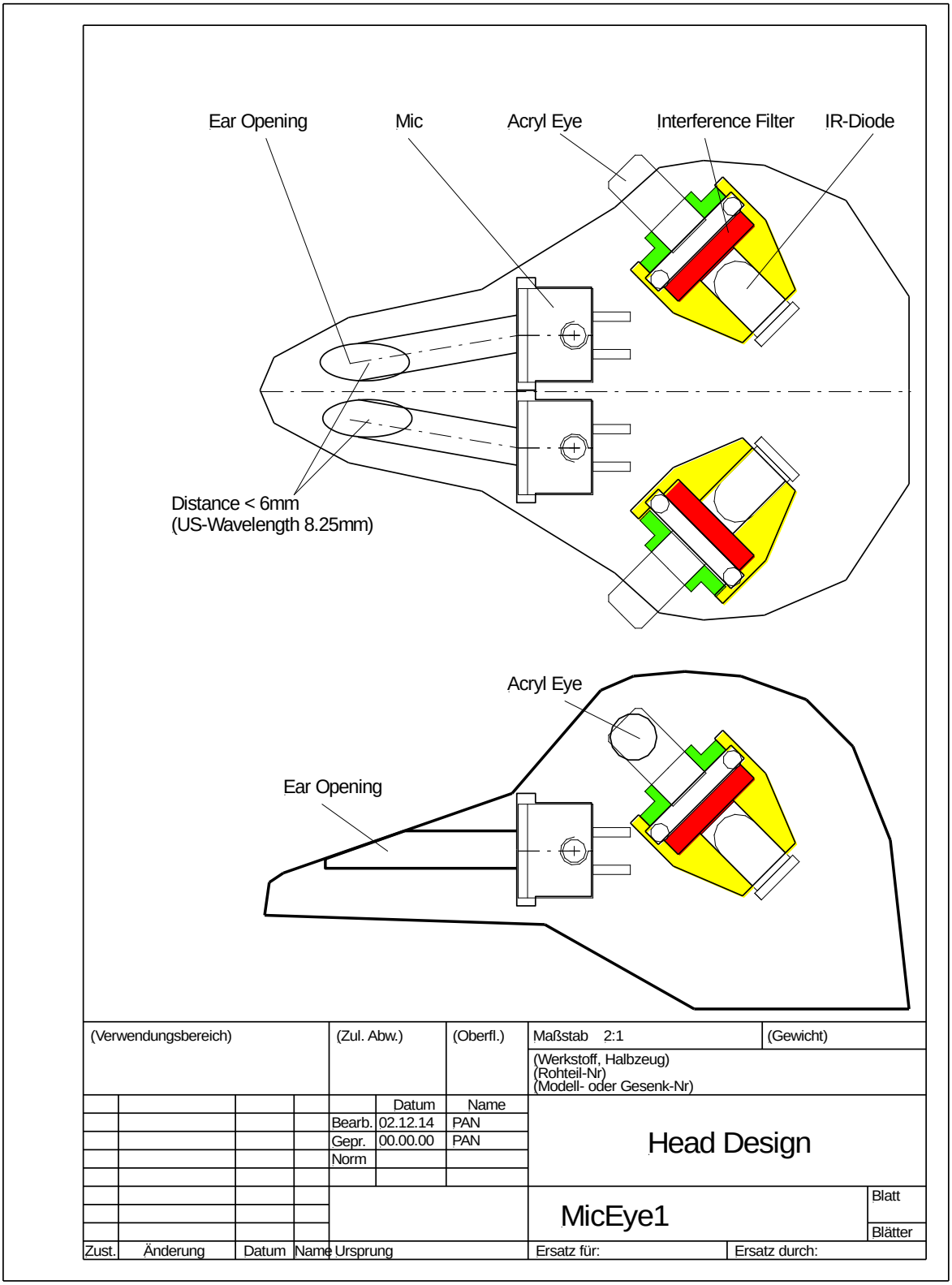


Fig. 2: Proposal Sensor Set-up

6. Recent Experiment

6.1. Test Setup

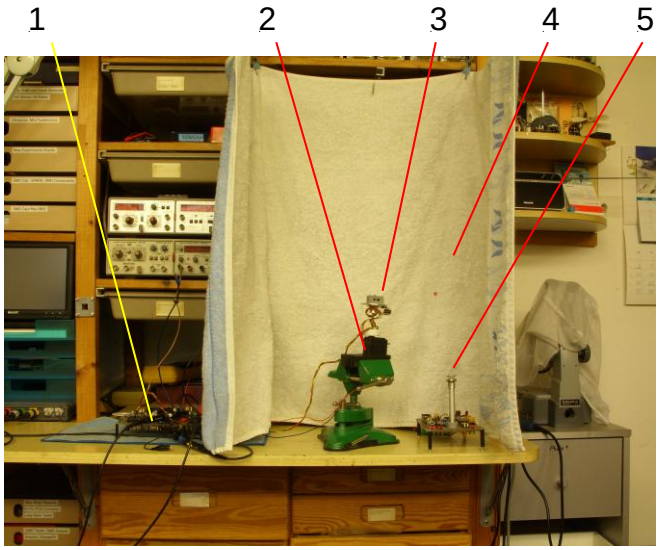


Fig. 3: Test Set-up

1: Receiver Board
2: Gear Motor for rotation
3: Two mics, spacing 6mm
4: Turkish towel for reflection attenuation
5: Omnidirectional US-Speaker.

The following experiments were performed at a distance of about 2 m in a small laboratory 4x5 m

Distance to Turkish towel <0.2m

6.2. Experimental results

Experiment indoors, Febr. 13th, 2015
Distance 2 Meter
Time Scale: 2sec/Div; Top: Sample; Middle: Direction; Below: Intensity

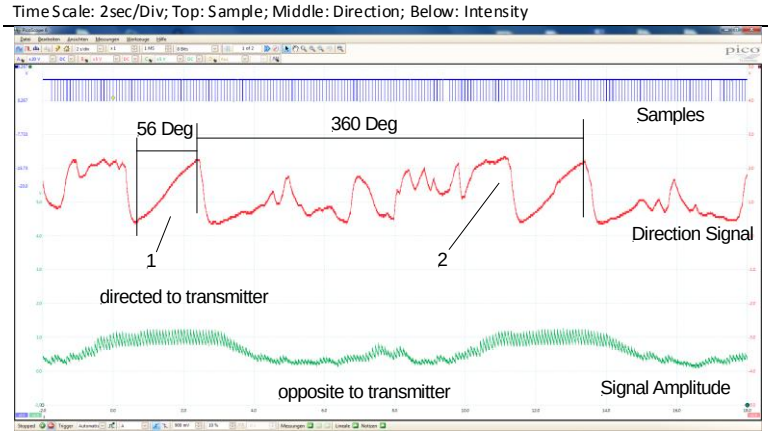


Fig.5: Left turn without range limiter

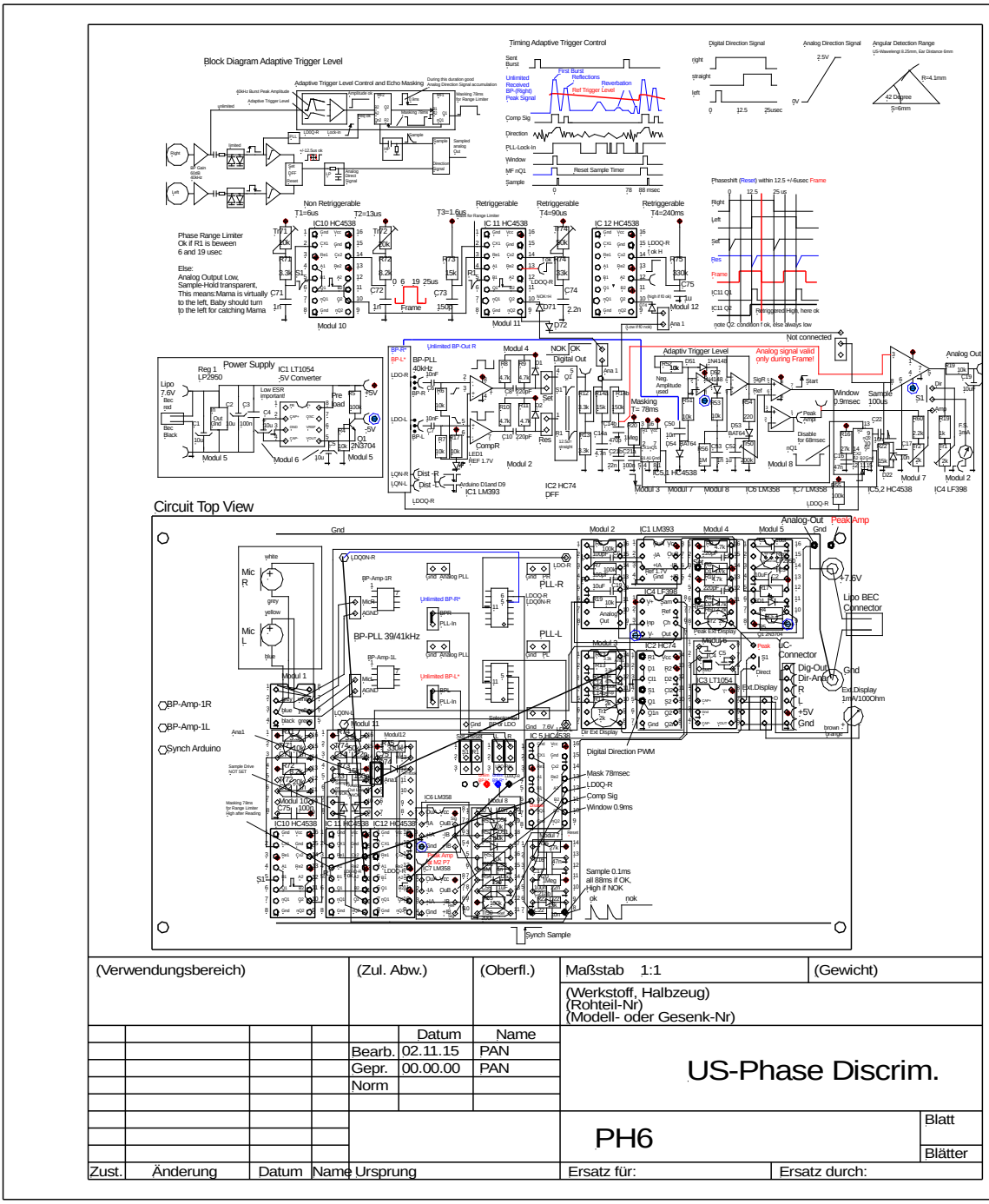
Fig.6: Left turn with range limiter

Experimental Results Comment:
Fig. 5 shows the direction signal with the received signal amplitude.
1: The direction signal is quite good within a measuring range of> +/-25 degrees.
2: Wrong direction signal.

Fig. 6. shows the effect of the range limiter realized with a digital circuit.
The direction signal is very good within measuring range of +/-18 degrees
3: Low before approaching zone from the left, good!
4: High before approaching zone from the right, good!
5: Still wrong direction signals mainly opposite to transmitter
6: Clear Maximum Acoustic Level!

7. Receiver Circuit with Timing diagrams

7.1. Circuit



(Verwendungsbereich)				(Zul. Abw.)	(Oberfl.)	Maßstab 1:1	(Gewicht)
						(Werkstoff, Halbzeug) (Rohteil-Nr) (Modell- oder Gesenk-Nr)	
				Datum	Name	US-Phase Discrim.	
				Bearb. 02.11.15	PAN		
				Gepr. 00.00.00	PAN		
				Norm			
						PH6	Blatt
							Blätter
Zust.	Änderung	Datum	Name	Ursprung		Ersatz für:	Ersatz durch:

Fig. 7: Receiver circuit

7.2. Timing diagrams

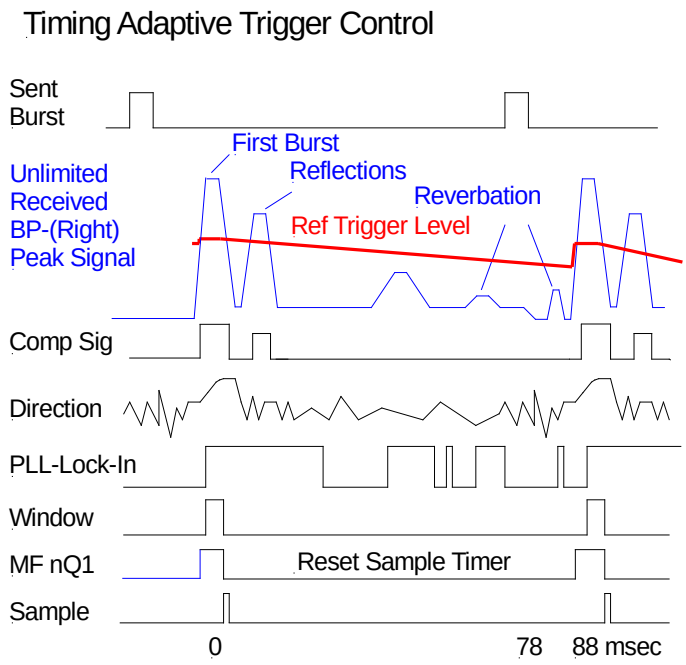


Fig. 8: Timing Adaptive Trigger Control

Comment:
The initial Trigger Signal from PLL-Lock-in appears at about 1.4 msec
(see Report 86, Fig. 7a)

This means, that the US-Burst should last longer than 2msec for proper operation.

But this it too long for masking reflections from near-by objects

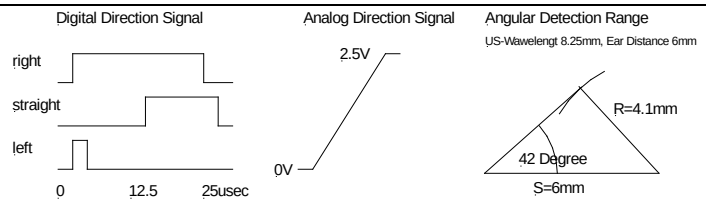


Fig. 9: Direction signal with ear spacing of s=6mm

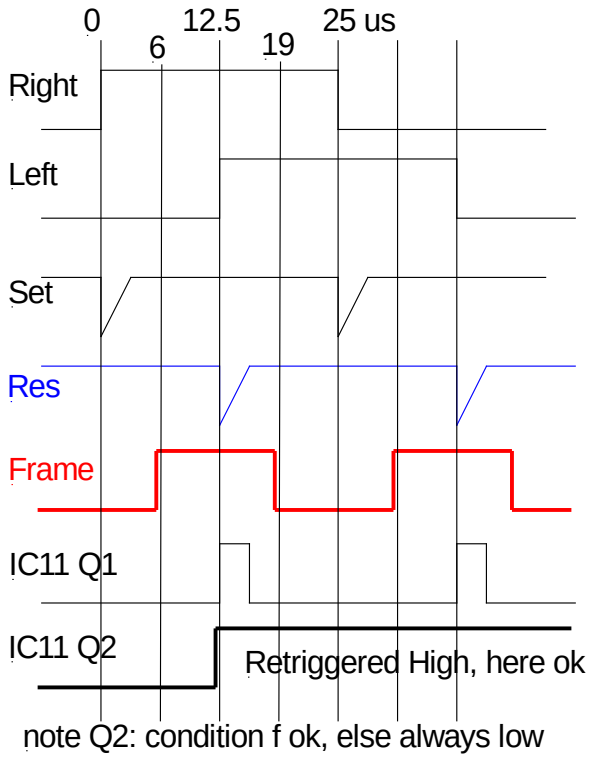


Fig. 10: Range limiter

The range limiter accepts Reset signals 6<t<19usec

However it accepts also Rest Signals in the range: (6+25)<t<(13+25usec)!

This means in practice that echo's within 31usec will be accepted, too!

8. Experiment with shadowed Mics

Purpose and background:

High frequency electromagnetic signals (transversal propagation mode) such as IR can be shadowed by a wall between the receiving sensors A and B. With analog or uC data processing of (A-B)/(A+B) an auxiliary (or main) direction signal can be obtained.

Let us try here the same with ultrasonic signals (longitudinal propagation mode!

8.1 Acoustic Shadow Setup

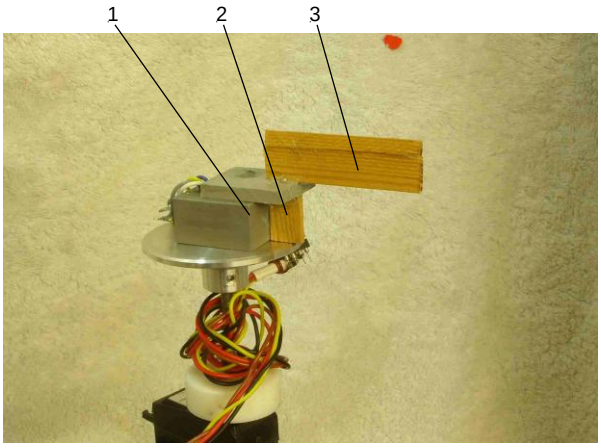


Fig. 11. Acoustical Shadows

1. Dual Mics, Spacing s=6mm
2. Short Shadow
3: Long shadow

8.2. Experimental results

First without Acoustic Shadow:

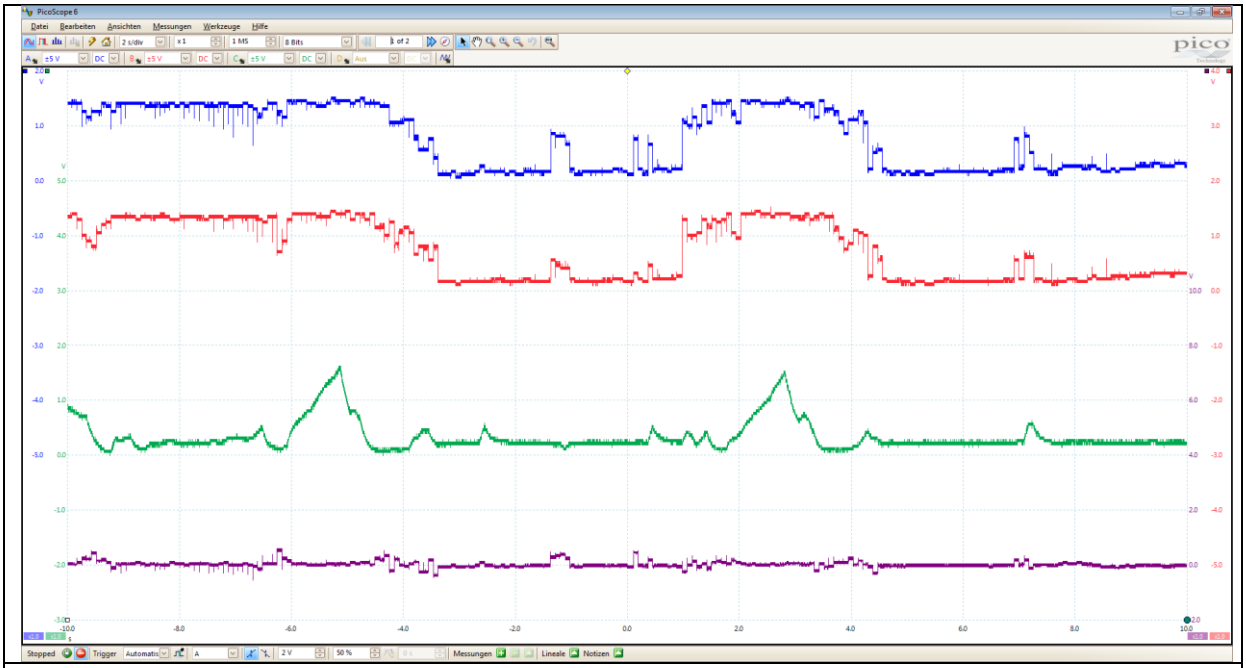


Fig.12. Experimental Results without Acoustic Shadow, Slow rotation, 2sec/Div
Distance to the rear Turkish towel 0.2m, transmission distance 2m
Top: A: Peak Acoustic Signal Left
Below: B: Peak Acoustic Signal Right
Middle: C: Phase Signal with range limiter enabled
Bottom: Differential Signal A-B (here: should be zero at ideal conditions, ok)

Comment: Good direction phase signal, little reflection from the rear Turkish towel

Second: With Short and Long Acoustic Shadows:

Same settings as for Fig. 12.

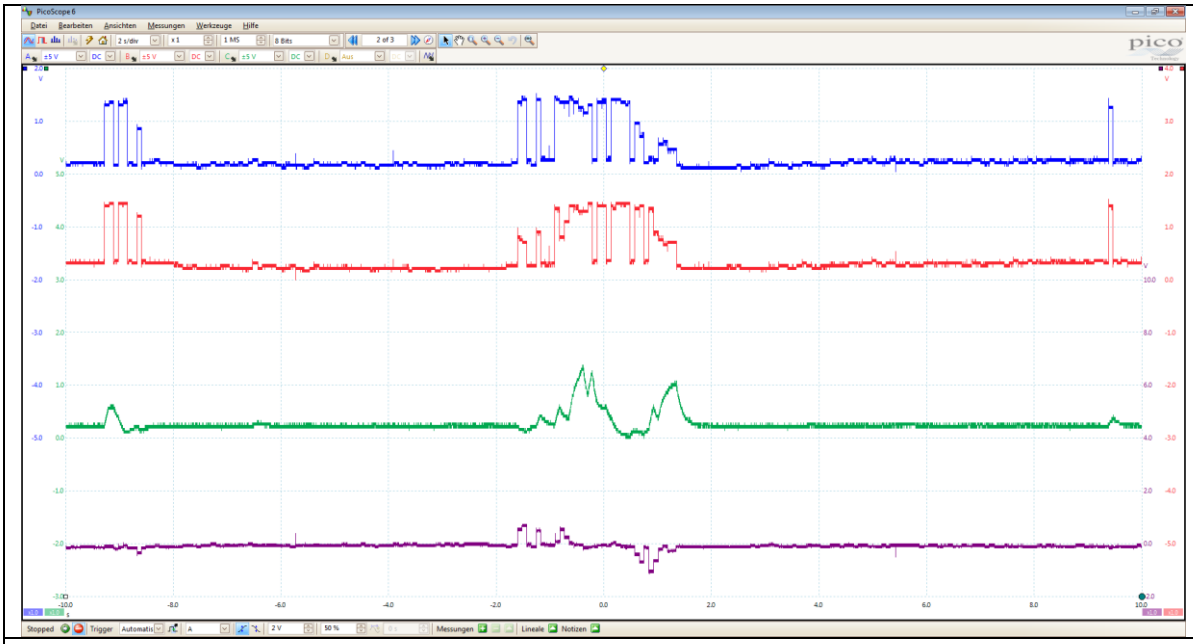


Fig.13: Short acoustic Shadow

Comment: There is a modest Signal A-B, but the Phase Signal gets quite disturbed!

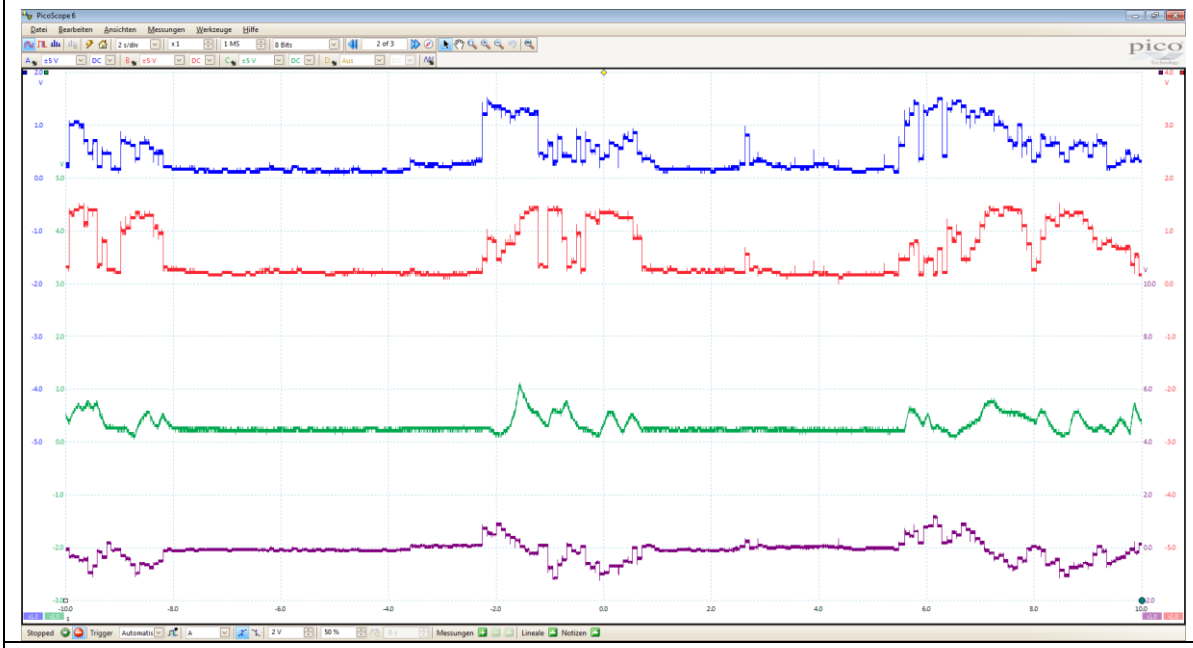


Fig.14: Long acoustic Shadow

Comment: There is a better Signal A-B, but the Phase Signal gets heavily disturbed!

Comment: The acoustic shadow is here not applicable by three reasons

- The Phase (Direction) Signal gets disturbed.
- The Receiver Mics must be turned VERY SLOWLY due to air turbulences.
- US should be regarded as a pressure cloud with longitudinal propagation, difficult to shadow!
- Fail-safe detection of the valid direction range might be possible with artificial intelligence. e.g. pivoting the Mics left/right by 10 degrees and checking the phase response!