

1. Introduction

Report 86 describes the principle of precise direction detection of short US-Bursts and Report 88 some experimental result. Here is a summary:

An ultrasonic burst of $f_0 = 40 \text{ kHz}$, here repeated all 88msec is emitted omnidirectional during 2 msec. The receiver consist of two mics, close together, a PLL operating as a tone detector (f_0 Lock-in), an adaptive trigger control and finally of a phase discriminator with sample hold.

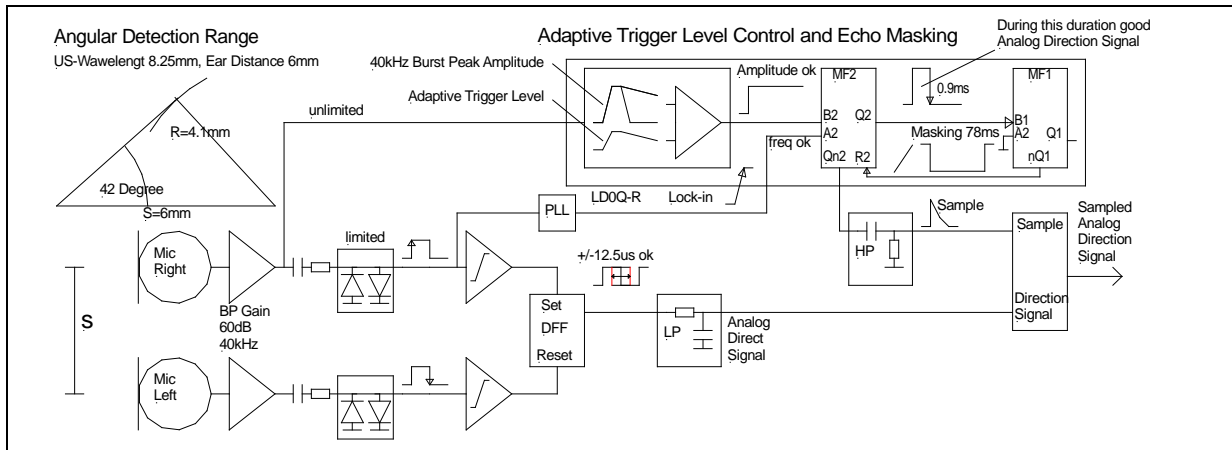


Fig. 1. Circuit Direction Measurement by Phase Difference Discrimination

The phase difference Mic Right to Mic Left is measured by set and reset of the DFF, giving a rectangular signal of 1 to 99 % Duty Cycle. The average voltage becomes the analog direction signal.

The adaptive Trigger Level follows the received sound amplitude. The PLL is used here as a tone detector for about $37 < f_0 < 42 \text{ kHz}$. If both amplitude and frequency of the burst are ok, the direction signal becomes sampled and hold up to the next correctly received burst. After sampling the Echo Masking prevents further sound reception for about 90 % of the burst interval period.

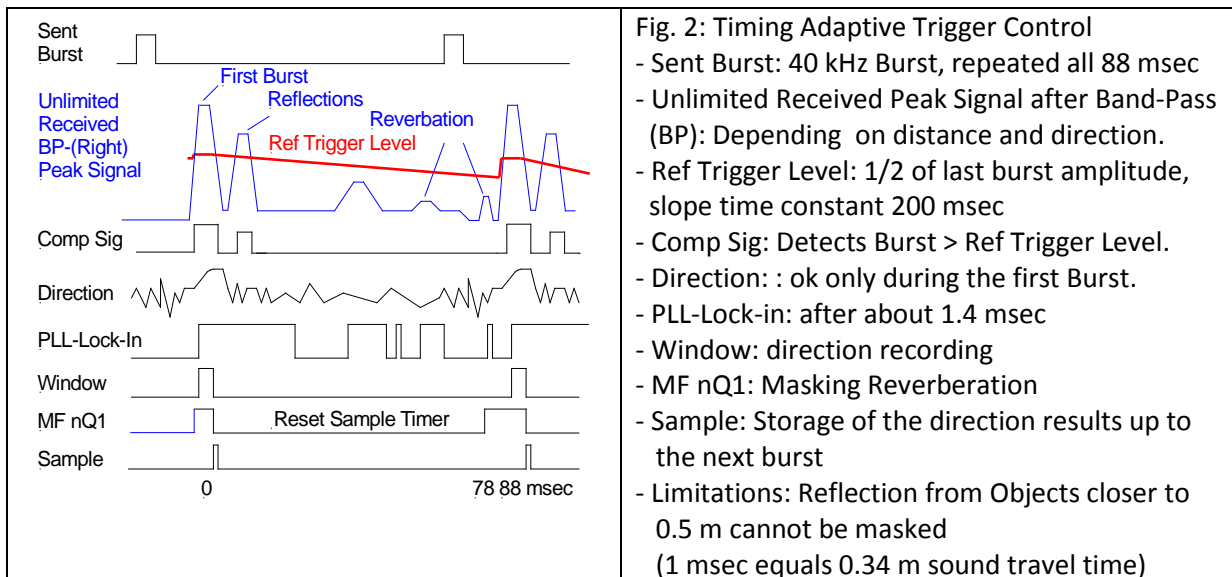


Fig. 2: Timing Adaptive Trigger Control

- Sent Burst: 40 kHz Burst, repeated all 88 msec
- Unlimited Received Peak Signal after Band-Pass (BP): Depending on distance and direction.
- Ref Trigger Level: 1/2 of last burst amplitude, slope time constant 200 msec
- Comp Sig: Detects Burst > Ref Trigger Level.
- Direction: : ok only during the first Burst.
- PLL-Lock-in: after about 1.4 msec
- Window: direction recording
- MF nQ1: Masking Reverberation
- Sample: Storage of the direction results up to the next burst
- Limitations: Reflection from Objects closer to 0.5 m cannot be masked (1 msec equals 0.34 m sound travel time)

2. Indoor stationary experimental results

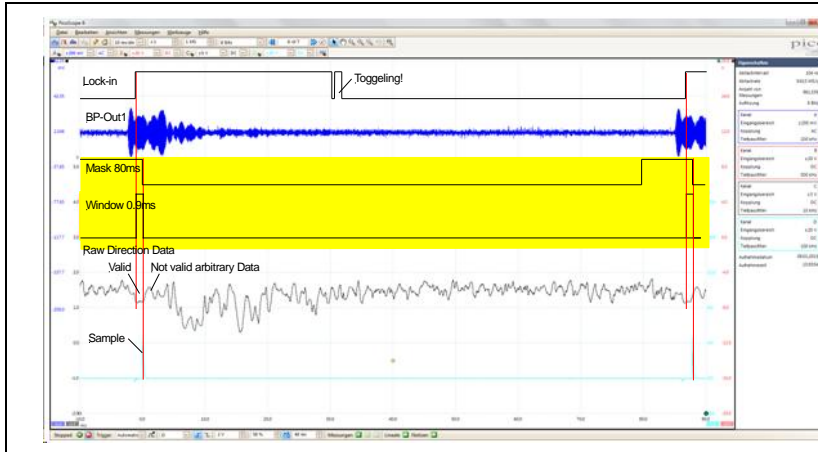


Fig.3: Results in Practice.
Traces from top to bottom:
- Lock-in, retarded 1.4 msec with toggling at the end at about 40 msec.
- BP-Out1 :first stage, unlimited sound amplitude.
- Masking 1 to 80 msec
- Window 0.9 msec for direction measurement.
- Raw direction data.
- Sample for Hold

3. Indoor experimental results with slowly rotating receiver

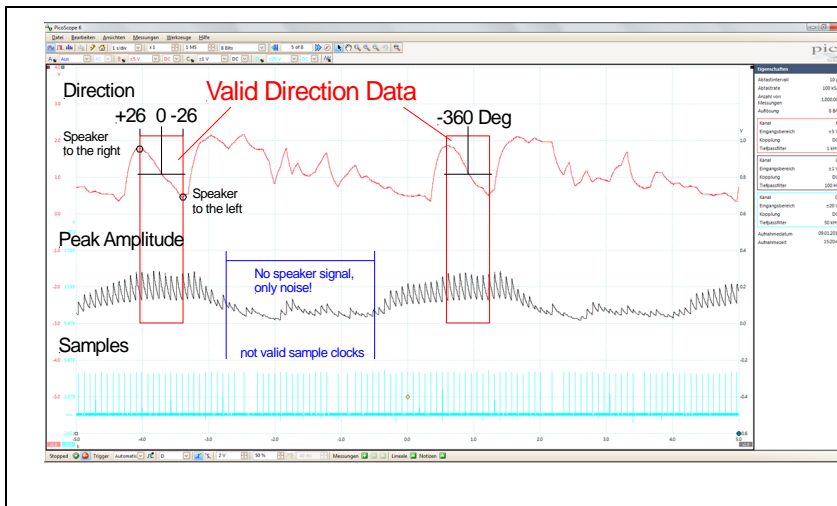


Fig. 4. Rotation $360^\circ/5$ sec: Direction signal and received signal amplitudes.

The direction signal is quite good within a measuring range of about ± 26 degrees.

However, it is impossible to find the valid direction range without help from other sensors, e.g. Opto System

4. Further experiments for direction and distance measurement

We will generate an US-Burst of $f_1 = 38$ kHz during 3 msec for direction measurement as shown above, followed by $f_2 = 41$ kHz during 2 msec for distance measurement (FSK, PLL, 5mm accuracy). The synchronization is planned now by the stop of the Opto IR t^2 ramp, which will give also an information about the valid direction range.

Next tasks:

- Measuring Period: about 132 msec (6 x 22 msec of the RC repetition rate) but HERE NO RC SYNCHRONIZATION for this Sensor performance investigation.
- Proposal for this FSK Burst 38/41 kHz during 5 msec (3 msec f_1 , followed 2 msec f_2)
- Proposal for a fast PWM, 1 to 50 % duty cycle, within about 25 msec (max 50 msec), beginning after the Ultrasound FSK, IR-Frequency at least 2 kHz.
- Proposal to enable the optical proximity sensor (not shown here), during 25 msec after PWM.

5. Combination of US Direction Data with Opto Direction Data

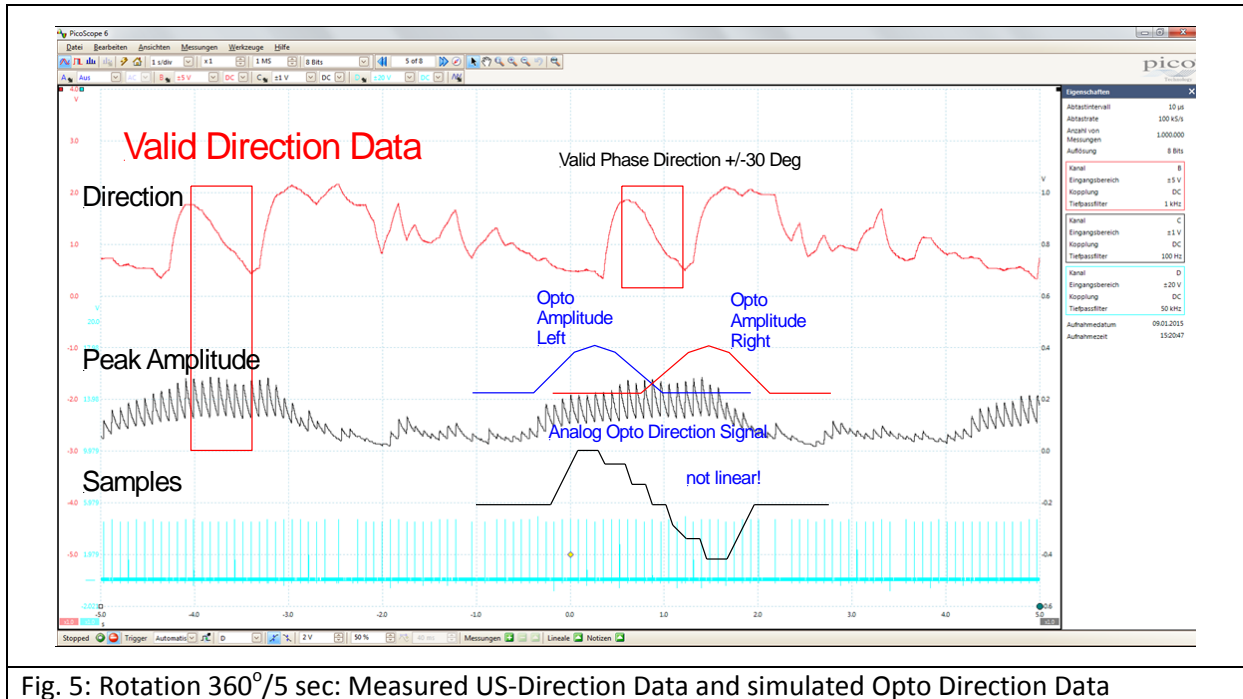


Fig. 5: Rotation 360°/5 sec: Measured US-Direction Data and simulated Opto Direction Data

Ultrasound Direction Detection:

The original information is a quite linear PWM with 40 kHz or 25usec Period, 1 % D.C. = left, 99 % D.C. = right.

The analog direction signal (see Fig. 5, top trace) is the LP filtered averaged amplitude of this PWM. However, there is no possibility to identify the valid direction range by rotation.

Opto Direction Detection

At present there is no experimental opto data available, work is still in progress!

But we may assume:

- Clear opto maximum amplitude left eye at about -40° and right eye at about $+40^{\circ}$
- Broad opto direction range, but not linear.
- Clear valid direction range detection by rotation clockwise and reverse.

6. Actor Data Mama and Sensor Data Baby

