82. Ultrasonic Direction Sensing by US-Phase discrimination **Draft 1.0**

UFO Doctor, Nov. 30th 2014

Abstract

The US phase processing for direction sensing has been proposed by Miru.

In fact, this principle works quite good with an omnidirectional exponential cone speaker with high phase purity, designed by UFO Doctor some months ago.

Performance on an open field, free from reflecting objects:

- Distance sensing by FSK: 0.1m<d<15m,
- Direction sensing by Phase discrimination: 0.2m<d<8m, Angle -20Deg<Phi<+20Deg

UFO Doctor tried to improve this system by a rotating US-speaker, hoping for an increased detection distances and less influence of reflecting objects. However, he failed in the real outdoors world.

1. First Outdoor tests with Omnidirectional Speaker

1.1. Material for the first test

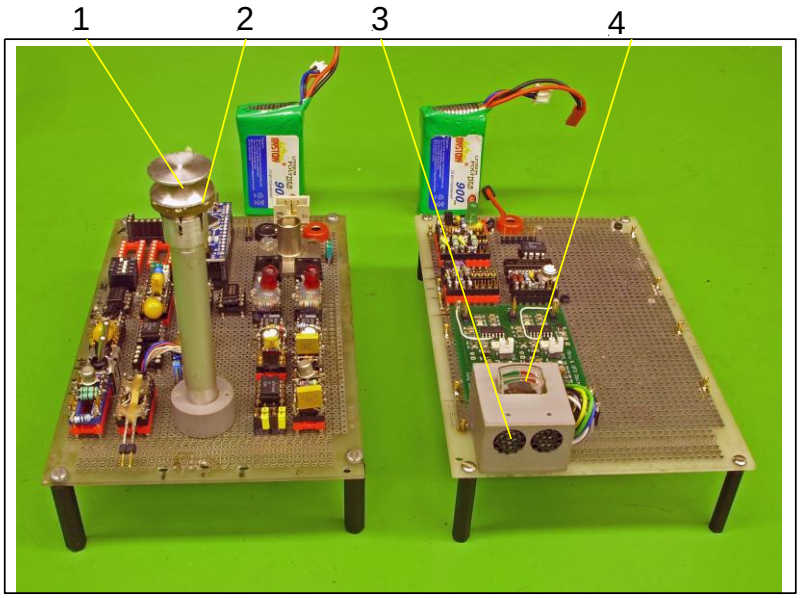


Fig. 1: Test Setup 1
1: Omnidirectional US-Speaker with Kobitone Transducer
2: IR-Light tower with 6 small IR-LED 840nm (later6 IR LEDs 940nm, 2W)
3: Kobitone Mics
4: Analog Direction Indicator

1.2. Outdoor Experiment 1

Conditions:

- Speaker supplied with 30Vpp by Voltage Doppler and Dual Buffer (Inverting, non inverting Outputs)
- Outdoor on a street, temperature 10 Deg Celsius's
- PLL tuned to 39kHz, US-Source 39kHz

1.3.Results:

- PLL-Lock-In: > 15 Meters
- Good Direction Signals: > 8 Meters
- Receiving angle: +/-20 Degree
- Very good Direction Signal also at near distances down to 0.2Meter.
- Good results if the US-Speaker is on a free field, more than 2m away from walls, cars, etc.
- Poor results if the omnidirectional Speaker is close to a reflecting obstacle.

2. Second test with Unidirectional Speaker

2.1. Material for the second test

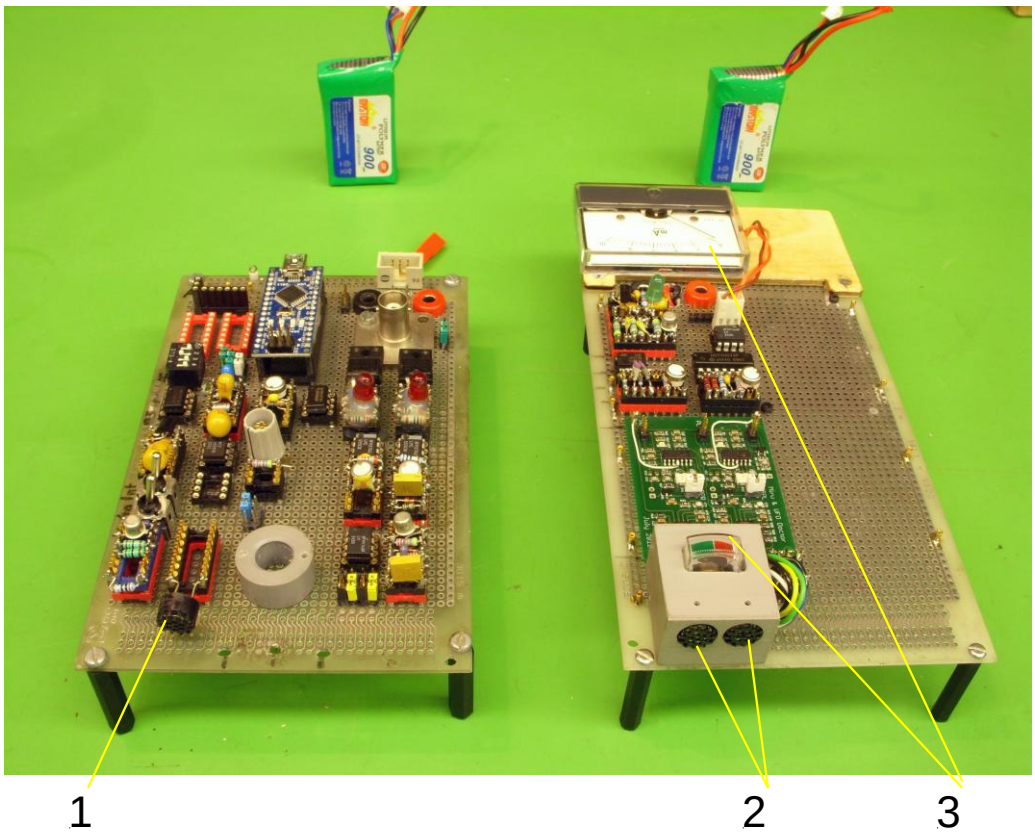


Fig. 2: Test Setup 2
1: Single Kobitone Transducer, directed to Receiver
2: Receiver Kobitone Mics
4: Analog Direction Indicators

2.2. Outdoor Experiment 2

Conditions:

- Speaker supplied with 30Vpp by Voltage Doppler and Dual Buffer (Inverting, non inverting Outputs)
- Outdoor on a street, temperature 10 Deg Celsius's
- PLL tuned to 39kHz, US-Source 39kHz
- IMPORTANT: Speaker directed to the receiver!

2.3. Results :

- PLL-Lock-In: max distance >30 Meters!
- Good Direction Signals: > 15 Meters!
- Receiving angle: +/-20 Degree
- Very good Direction Signal also at near distances down to 0.2Meter
- IMPORTANT: No negative effect of near-by reflective obstacles close to the US transmitter

2.4. Preliminary Conclusion

US-Speaker, directed to the receiver, and receiver directed to the transmitter works fine.
For omnidirectional operation sequential switched Speakers 0, 45,90 Deg, etc. might be a solution.
The receiver, of course, should be turned to the transmitter for US capture.

3. Indoor Experiment: Jitter by moving persons near the Omnidirectional Speaker

Conditions:

- Laboratory room 5x4m with many obstacles such as machinery, work bench. etc
- Distance US-Speaker-Mic: 2.5m
- One Person approaching to Speaker and/or Mics (not in between Speaker-Mic!)

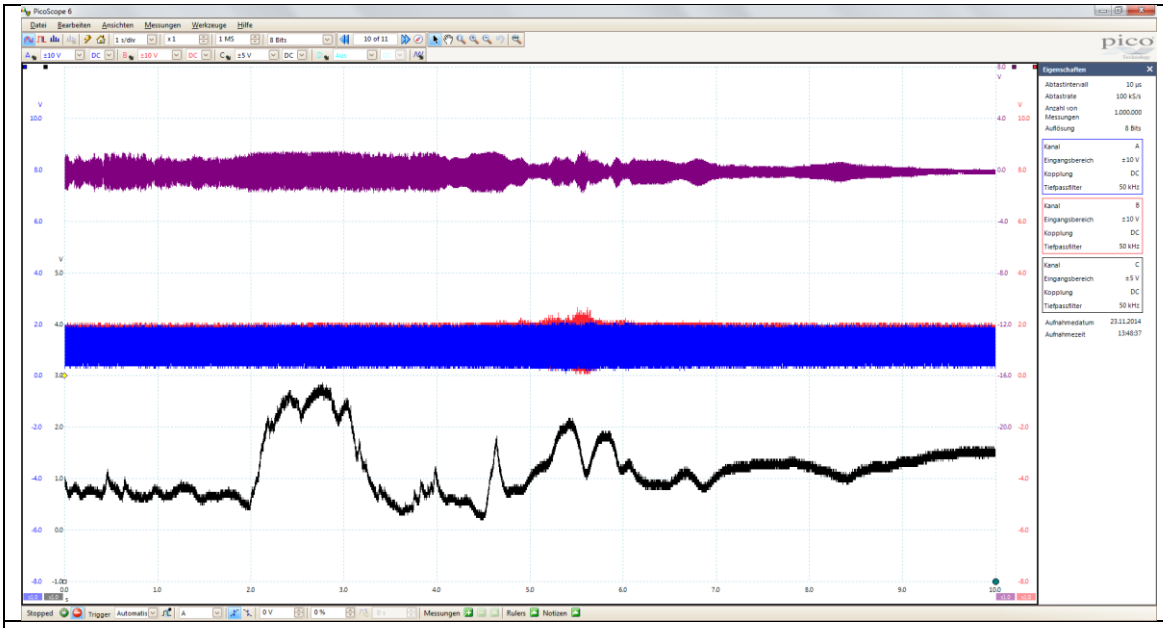


Fig. 3a: Omidirectional Speaker
Top: Channel A-B
Middle: Channel A: Phase-Left, Channel B: Phase-Right
Below: Channel C: Analog Direction Signal, 1V/Div: 3.3V equals to +/-20 Deg

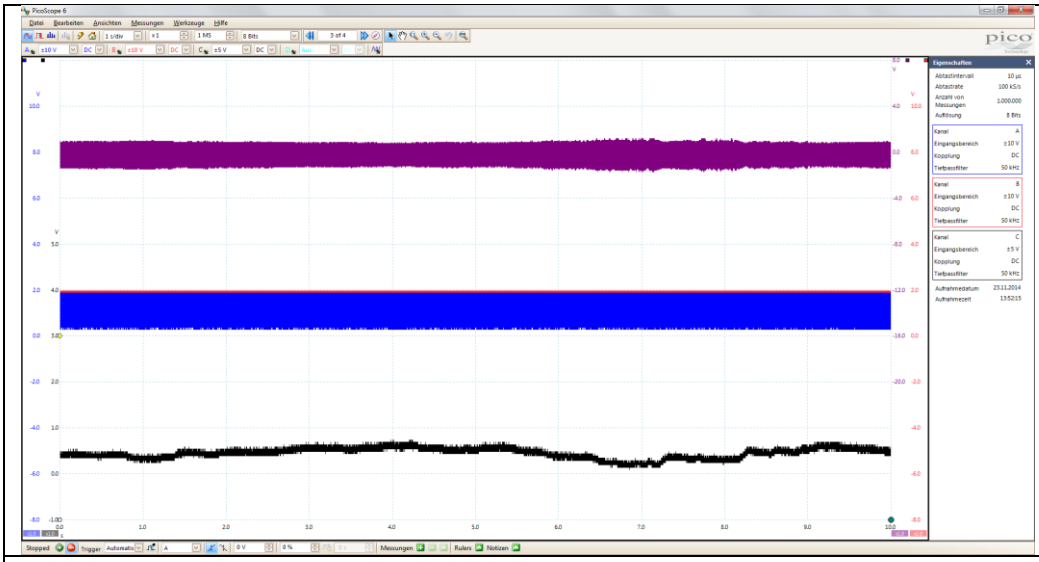


Fig. 3b: Single Kobitone Speaker directed to Mics
Top: Channel A-B
Middle: Channel A: Phase-Left, Channel B: Phase-Right
Below: Channel C: Analog Direction Signal, 1V/Div: 3.3V equals to +/-20 Deg

Comment:

A small laboratory room is not representative for outdoor conditions, but this experiment shows clearly the benefit of on single US-Speaker directed to the receiving Mics!

4. Outdoors Experiment on an almost empty parking lot, 30x20m

4.1. Test Situation

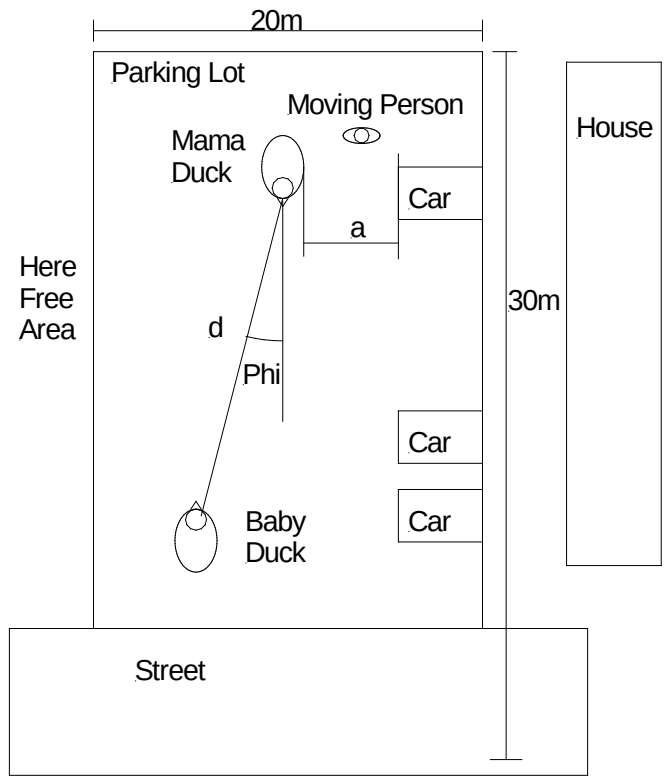


Fig.4:
Test Set-up on a parking lot

Conditions:
Clear weather
10 Deg Celsius

4.2. Results with Omnidirectional Speaker

1. Optimal conditions: distance to car >2m, no moving person nearby:
Lock-in Range > 30 m, Good Direction Signals > 20m
2. Mama Duck a < 1m to car:
Lock-in Range <20 m, Good direction Signals < 3m, heavy influence of a moving person nearby

4.3. Results with Unidirectional Speaker

1. Optimal conditions: Speaker directed to Baby, distance to car a>2m, no moving persons:
Lock-in Range >> 30 m, Good direction Signals >> 20m
2. Mama Duck a < 1m to car:
Lock-in Range > 30 m, Good direction Signals > 20m, no influence of a moving person near by
3. Angle of US-reception > 45 deg, Baby sideward's, but looking to Mama

5. Experiments with Rotating Unidirectional Speaker

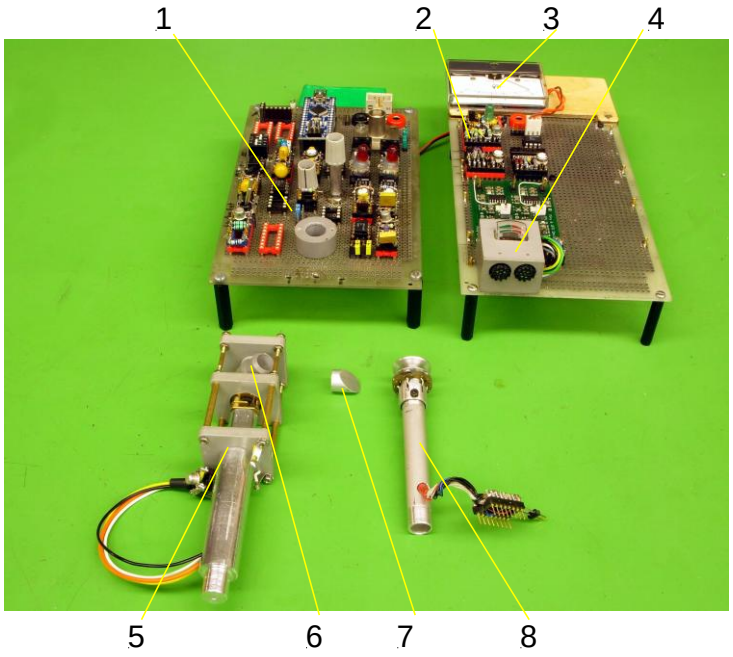


Fig.5: Rotating US-Beam and Omnidirectional Speaker.

1: US Transmitter Board
2: US Receiver Board
3: Direction Indicator
4: Receiver Mics, with 12.6mm distance for Angle Detection +/-20 Deg
5: Speaker Rotator with
6: Exponential Horn
7: Acoustic Mirror 45 Degree
8. Standard Omnidirectional Speaker

5.1. Indoor Experiments

- Laboratory room 5x4m with many obstacles such as machinery, work bench. etc
- Rotating exponential horn
- Distance US-Speaker-Mic: 2.5m
- Start with Speaker and Mic in-line, when rotation of the speaker with about 180 Deg/sec

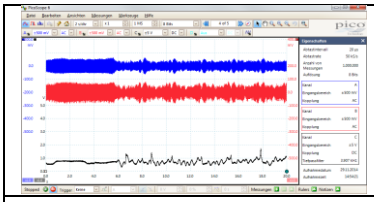


Fig. 5b: Receiver +20 Deg
Top: US-Amplitude left
Middle: US-Amplitude right
Below: Direction Signal

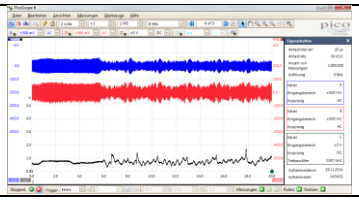


Fig. 5c: Receiver 0 Deg
Good direction signal at maximum sound amplitude

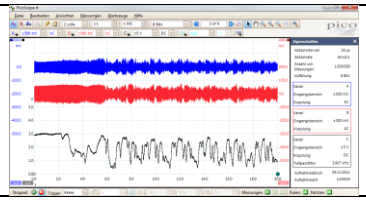


Fig. 5d: Receiver -20 Deg
Quite good direction signal at maximum sound amplitude

Comment:
Quite good direction signals if speaker is turned towards the receiver, but must be synchronized and processed with the received US maximum intensity, which is not as easy to discriminate!

5.2. Outdoor Experiments

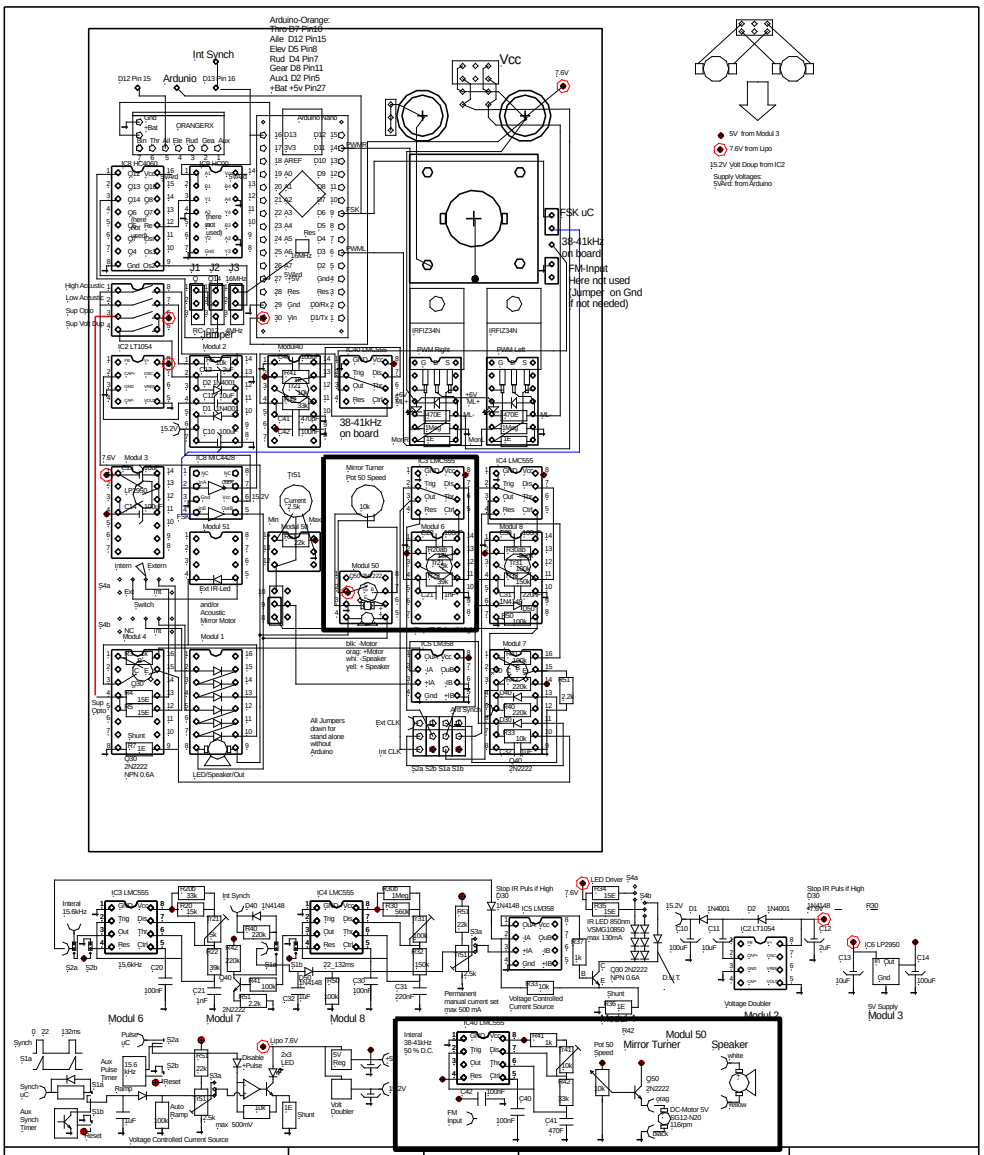
- The Speaker rotation speed should be less than 60 rpm, since the PLL losses the track if the Speaker is not in line with the receiving Mic
- The Speaker rotation speed is limited by the time for the decline of the reverberations, too
- Lock-in Range >20 m, Good Direction Signals >8m (but needs to be processed!)

5.3. Preliminary Conclusion

A rotating US-Speaker is not good in practice! Keep the omnidirectional Speaker!

6. Circuits and drawing of the mechanical parts

6.1. Circuit 39kHz Transmitter



(Verwendungsbereich)				(Zul. Abw.)		(Oberfl.)	Maßstab 1:1	(Gewicht)
							(Werkstoff, Halbzeug) (Rohteil-Nr) (Modell- oder Gesenk-Nr)	
					Datum	Name		
				Bearb.	11.29.14	PAN	39kHz Transmitter	
				Gepr.	00.00.00	PAN		
				Norm				
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								Blätter
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Fig. 6.1. Circuit 39kHz Transmitter

6.2. Circuit 39kHz Transmitter

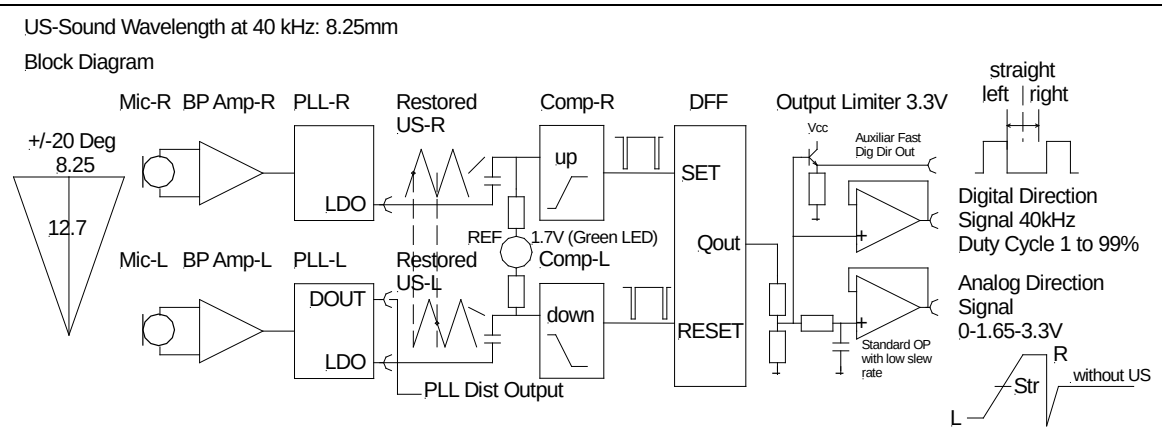

Fig. 6.2: Block Diagram

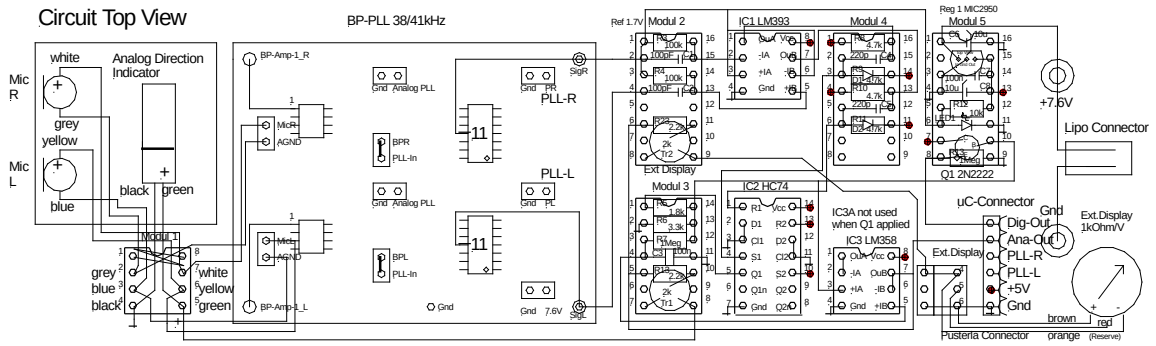

Fig .6.3. Circuit 39kHz Transmitter

6.3. Drawing Rotating Speaker, Mechanical Set-up

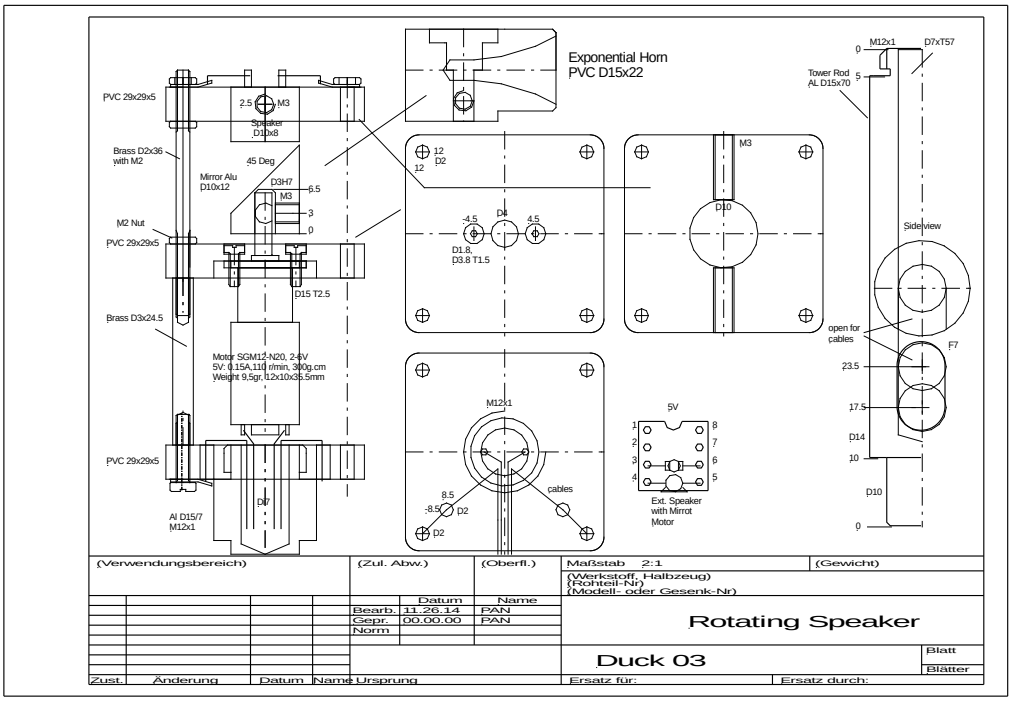

Fig.6.3. Drawing Rotating Speaker