INTERNATIONAL SYMPOSIUM on MUSICAL and ROOM ACOUSTICS

ISMRA 2016

September 11-13, 2016

La Plata, Buenos Aires, Argentina

Instrument Making: Paper ISMRA2016-49

Design and development of active ribbon microphone with variable polar pattern

Emilio Luquet[a], Nicolás Valese[b], Mariela Alba[c], Sebastián Olivera[d], Alexander Marino[e], David Chaikh[f], Francisco Ruffa[g]

[a] Universidad Nacional de Tres de Febrero, Argentina, emilioluquet@gmail.com
[b] Universidad Nacional de Tres de Febrero, Argentina, nicovalese@hotmail.com
[c] Universidad Nacional de Tres de Febrero, Argentina, marielalba@hotmail.com
[d] Universidad Nacional de Tres de Febrero, Argentina, olivera.untref@gmail.com
[e] Universidad Nacional de Tres de Febrero, Argentina, marinoalexander5@gmail.com
[f] Universidad Nacional de Tres de Febrero, Argentina, dch@spsonido.com
[g] Universidad Nacional de Tres de Febrero, Argentina, fruffa@untref.edu.ar

Abstract

A prototype of a top level ribbon studio microphone was designed and is being constructed. In order to improve efficiency and enlarge the applicability of the transducer, a cardioid polar pattern configuration was achieved through acoustical design in addition to the typical bidirectional polar pattern for this types of microphones. In this paper, a system to calibrate the ribbon was developed. Contrary to most of this type of microphones, the current prototype includes the design of a phantom powered preamplifier, which implements a low noise JFet to obtain a 40 dB output gain. Due to its harmonic characteristics, the JFet mic preamplifier acquires a unique sound which emulates valvular circuits. To compare in a representative manner the performance of the microphone, technical specifications were measured according to international Standard.

Keywords: Ribbon microphone, Active, Multi pattern

Design and development of active ribbon microphone with variable polar pattern

1 Introduction

Conventional ribbon microphones (RbM) are velocity or pressure-gradient type transducers, meaning an electrical output is generated based on the variations of the velocity of the particles of a sound wave displacing the diaphragm from its equilibrium position. Its principle of operation makes its polar pattern to be naturally bidirectional, although some attempts have been made to adapt the polar response of this type of microphones to non-directional and unidirectional patterns.

The concept of a poly-directional RbM was first introduced by Dr. Harry F. Olson in 1944 through the combination of a pressure and a velocity ribbon transducer in one single element [1]. The device consisted on a ribbon held in between the gap of a permanent magnet with one of its sides fully exposed to the atmosphere while the other side was connected to a damped acoustic labyrinth. The connecting path exposed part of the ribbon through an aperture, by which, modifying its size, the polar response of the microphone was turned from bidirectional to omnidirectional, passing through a cardioid pattern. One of the disadvantages observed by Olson in this system was the difference in output energy between the bidirectional and the non-directional patterns [2].

Other configurations implemented two vertical in-line ribbons, or a longer separated in halves single ribbon, in which the upper transducer presented both front and rear exposed to the atmosphere, whereas the lower one had one of its sides derived to a pipe or damped acoustic labyrinth. As in the model discussed above, this created the combination of a pressure and a pressure-gradient ribbon microphone, which allowed obtaining different polar patterns by summing portions of each output.

Since then only few different commercial models have achieved a sustained production over time, although highly used in broadcasting, the motion picture industry, and still appreciated by many audio engineers nowadays.

In this paper a prototype of a top level ribbon studio microphone was designed and is being constructed. For the current prototype the double ribbon setup was chosen, although two main difficulties remain to be solved.

2 Transducer

2.1 Magnetic Engine

The microphone transducer is composed by two independents magnetic motors. A bidirectional response characteristic of the gradient pressure microphone was complemented with a magnet motor with omnidirectional polar pattern. Through the sum of the bidirectional with the omnidirectional responses, a unidirectional response was achieved to certain frequency range. In this way, it is possible to select between a bidirectional and a unidirectional (cardioid) polar patterns.

To stablish a strong magnetic field in each magnetic motor, two magnets were used. The material of the magnets was grade N52 neodymium with nickel coating. In this way, the movement of the ribbon into a perpendicular magnetic field produces a proportional induced electrical signal in the ribbon terminals which is conveyed toward the audio transformer. Implemented magnet sizes were 25, 9 and 9 mm. It was expected achieve an enough signal level avoiding as much as possible influence on acoustic field of the magnetic motor.

The magnetic motors ribbons were made with a thin foil of 99.1% aluminium. In order to obtain a flat frequency response, two ribbons from different thicknesses were compared, each one with two corrugation types. The implemented thicknesses were 1.8 and 2.5 µm, while the corrugation rates were 2 and 4 mm. A Log Sine Sweep signal was recorded using each ribbon as acoustic-electric transducer with the same magnets. It was recorded into an acoustically treated enclosure with low background noise with a distance of 1 m between the loudspeaker and the tested ribbons. Figure 1 shows the implemented measurements setup. In addition, to exclude enclosure influence, signals were recorded at the same time with a high quality measurement microphone with known frequency response. Twelve repetitions for each configuration were recorded in order to reach a normal distribution in the measures.

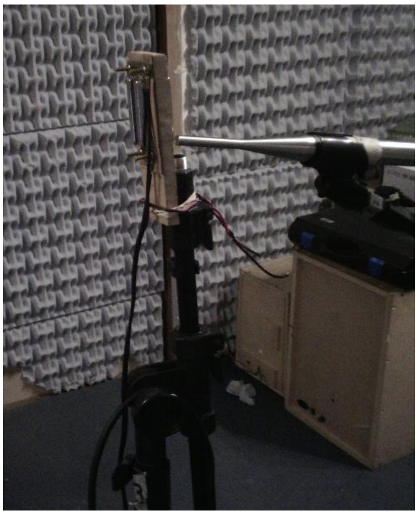

Figure 1: Measurement of various ribbon configurations

A self-designed structure was constructed to assemble the elements of the two magnetic motors, the acoustical labyrinth, the audio transformer and the circuit board. Figure 2 shows the first designed structure with one magnetic motor.

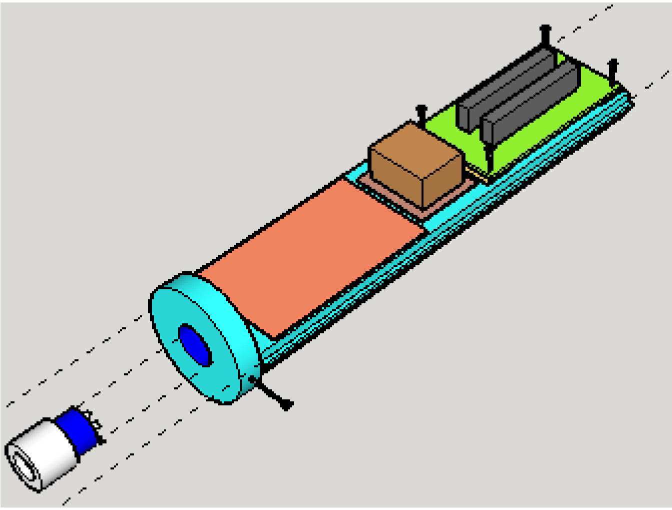

Figure 2: Inner structure.

2.2 Acoustic Laberynth

With the purpose of reach an omnidirectional polar pattern taking as a basis a ribbon microphone, an acoustical labyrinth was designed. It is composed by multiple ways with different lengths according to the lengthwaves of the operative frequency range. This acoustic phase inverter is represented in the equivalent circuit as an inductive-resistive (LR) network. The designed labyrinth was built through 3D printing.

3 Signal Conditioning

Regarding the signal conditioning of the RbM this process is divided into two main stages. The first one is the one which almost every commercial RbM in the market offers and it is an output signal amplified with a low noise high quality transformer. In addition to this, it was included a signal preamplifier offering the possibility of being bypassed from the signal path. Figure 3 shows the signal path including the preamplifier; both stages are detailed in the following sections.

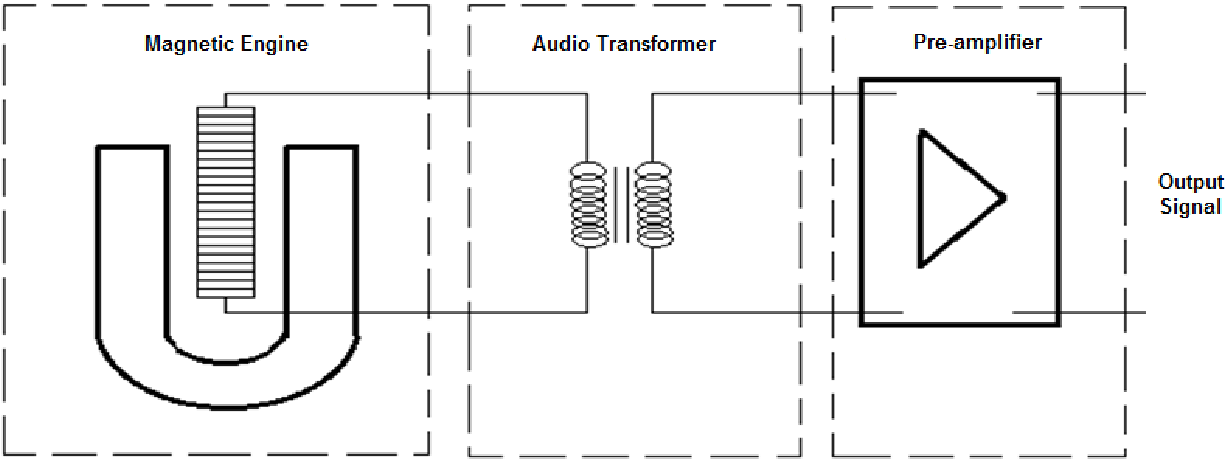

Figure 3: Signal path within the RbM.

3.1 Transformer

The transformer stage is crucial and cannot be replaced in the design of a RbM, the fact that it is a multipurpose stage determines that this kind of transformers have to be carefully built and design for this specific application. This device has mainly two objectives that must accomplish with merit in order to obtain a high quality microphone.

- Must provide an immediate gain stage as noise less as possible.
- Must provide a low impedance matching network.

The output signal level of a ribbon engine is usually around 0.1 mv, this is a value 50 times lower than the output of a regular moving coil microphone. Such low level signal is not in conditions to be transmitted as it is extremely susceptible to noise. Moreover, the out impedance of the ribbon is extremely low and therefore a step up transformer with ratio 1:37 was implemented providing an optimum balance between output impedance and output level of the microphone without the preamplifier. It is important to mention that the transformer needs to be located as near as possible to the ribbon seeking for the shortest path for the low level signal. This job cannot by replaced with an active circuit as the latter would not be capable of keeping a reasonable noise floor. It was decided to use a transformer as noise less as possible and with a plane frequency response in the audible spectrum (20-20000Hz).

Figure 4: Lundahl LL2913 microphone 1:37 transformer.

3.2 Audio Preamplifier

The audio preamplifier circuit is an optional feature that was decided to be included in the design of the RbM. This one has as a gain of 26.5 dB and it was designed with three stages including a negative feedback loop which achieves a linear response increasing the level of the signal without modifying any other parameter within the frequency range of interest. This one is limited by the designed preamplifier and goes from 16 to 80000 Hz. In addition to this, the idea of including together with the preamplifier a circuit capable of adding a specific amount of the second harmonic from the input signal was added to the design. This circuit contains one JFet and is polarized so as to achieve a 4% second harmonic distortion.

The circuit contains a potentiometer which controls the mix between the linear preamplifier signal with the 4% distorted one, letting the user go from a 4% distorted signal to a totally clean one passing thru all the mixes in between. As it was explained before the design also includes a switch which allows bypassing the active stage of the signal path and going directly from the transformer to the output of the microphone. Figure 5 illustrates the different parts of the signal conditioning section.

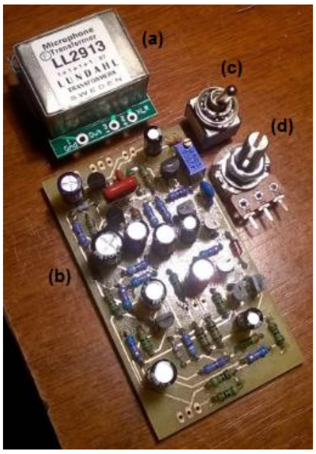

Figure 5: (a) Lundahl LL2913, (b) Preamplifier and second harmonic exciter circuit, (c) Preamplifier bypass switch, (d) Mix knob between clean preamplifier signal and the distorted one.

4 Measurements

4.1 Preamplifier Measurements

Electronic measurements were realized in order to test the preamplifier and the second harmonic exciter frequency response. Both are shown in figures 6 and 7.

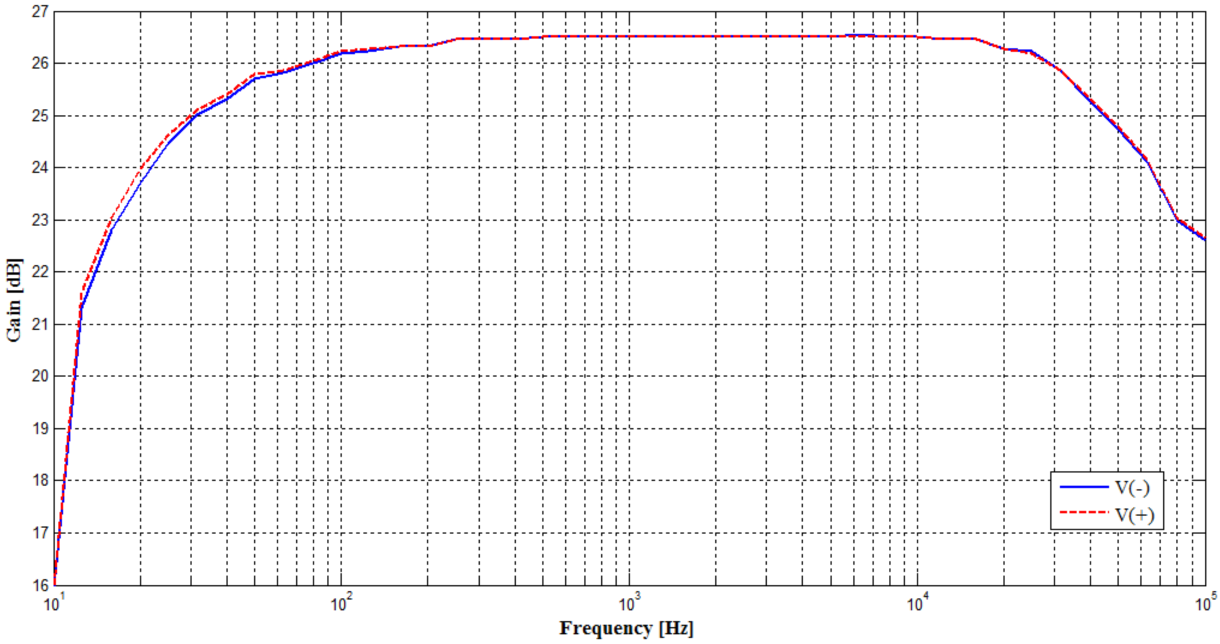

Figure 6: Frequency response of the preamplifier circuit specified for positive and negative phase output signals.

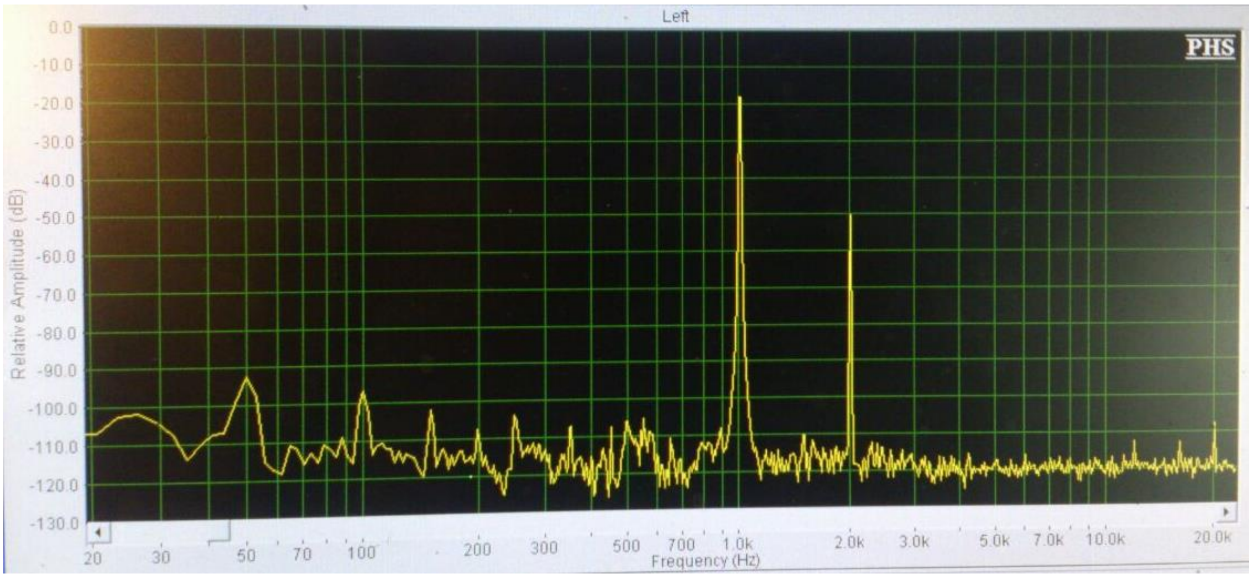

Figure 7: Frequency response of the second harmonic exciter circuit with a 1kHz input signal.

Figure 5 shows the frequency response of the preamplifier circuit without the influence of the second harmonic exciter. The frequencies were the gain reaches -3dB in reference to the gain at 1 kHz (26.5dB) are 16 Hz regarding low frequency and 80 kHz as regards the upper side of the spectrum. This was intentionally designed in order to eliminate every frequency which do not belong to the range of interest and which may cause an oscillation in any of both circuits.

Moreover, figure 7 shows the frequency response of the second harmonic exciter with a 1 kHz input signal. It can be clearly seen how the second harmonic (2 kHz) is being amplified above the rest of them.

4.2 Frequency Response Measurements

After measurements, the recorded signals were processed to compare the performance of the ribbon configurations. The four frequency responses obtained were compared, reaching the best performance with the 2.5 µm thickness foil with a 4 mm corrugating rate. Figure 8 shows the comparison of the measured responses.

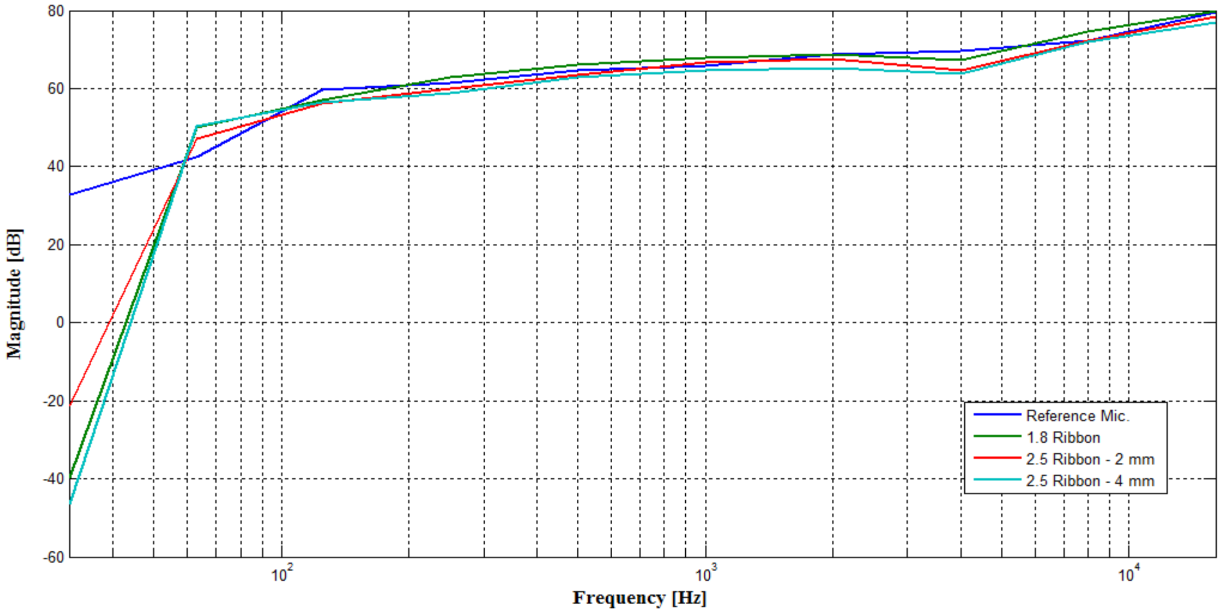

Figure 8: Frequency response of the ribbon configurations tested.

5 Conclusions

A Ribbon microphone with additional improvements was designed and it is on making process. In addition to the bidirectional polar pattern, a second magnet motor with omnidirectional polar pattern was attached. As result, it is possible to select between bidirectional and cardioid polar pattern, presenting more versatility in its applications. It is expected reach omnidirectional response through the implementation of an acoustical labyrinth which is in designing process. By means of finite elements method simulation, widest possible frequency operation range is being sought.

Regarding the electrical handling of the signal, a high quality transformer was implemented as first stage of signal gain. Additionally, a self-designed active preamplifier was made. It has as main features linear frequency response from 16 to 80000 Hz, low noise, balanced output and offers the possibility to mix the original signal with the same one passed through an JFet second harmonic exciter. This has the characteristic of emulate the valvular circuits sound.

As future work, it is expected make the designed acoustical labyrinth by 3D printing to assemble it on the internal structure of the microphone. After this stage, the external structure design will be finalized to make it. Thus, to quantify the microphone performance, technical specifications will be measured in anechoic chamber according international Standard [3].

Two main problems remain to be resolved regarding the multi polar pattern design. Due to diffraction, it is expected that the non-directional transducer will present an irregular pattern for frequencies above 2 kHz when the sound source is located 180° from the centre of the microphone. In addition the omnidirectional ribbon sees the damped labyrinth as a resistive load, which reduces its output. The fact that an active preamplifier is specially designed and attached might be a plausible solution for the latter by achieving a greater amplification for that specific output signal. However, it is possible that this resistive load on the back side of the ribbon contributes not only to a lower output signal but also to a distorted one. For this reason the implementation of an inertance leaking control valve is being considered.

Acknowledgments

This research was supported by UNTREF Grant for ISMRA 2016 Congress.

References

[1] Olson, H. F. Paper title. *Proe. Insf. Rad. Eng*, Vol. 32, No.2, 1994, p 77.

[2] Olson, H. F. *Elements of Acoustical Engineering*, D. Van Nostrand Company, Inc, Princeton (USA), 2nd edition, 1957, pp 298-303.

[3] CEN, European Standard EN 12354-2: *Building acoustics - Estimation of acoustic performance of buildings from the performance of elements - Impact sound insulation between rooms*, Belgium, 2002.