Final Written Review :
Digital Emulation of the Rotary Loudspeaker Effect

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ABSTRACT

This final written review will focus on the digital emulation of the Rotary Loudspeaker effect to be sold as a Digital Audio Plugin, called the ROTATRON which can be used with any Digital Audio Workstation (DAW). This report will outline the problems faced by recording an original Leslie speaker, and how the ROTATRON can be used to faithfully represent the sound of an original Leslie speaker.

1. Introduction

The original Leslie speaker can be considered to be an iconic sound in Western popular music, mostly associated with the hammond organ. However, Leslie's have been modified to be used with guitars, as well as vocals. Songs such as The Beatle's "Tomorrow never knows" has a vocal sound processed by a Leslie. Soundgarden's "Black Hole Sun" has a distinctive guitar sound which was achieved by playing a guitar through a Leslie Speaker. These are a few examples, not to mention the countless classic organ sounds which have been achieved with the Leslie.

The Leslie Speaker was invented in 1949 by Donald Leslie [1]. A Leslie speaker typically combines an amplifier with a two-way speaker system - a low-frequency driver (bass speaker), and a high-frequency driver (treble speaker). The sound output of the speakers passes through separate rotating mechanical devices. The treble speaker is coupled with a rotating horn, while the bass speaker is coupled with a rotating drum. [2]

Fig. 1 - Leslie Speaker Internals
Source: Unearthing the mysteries of the Leslie Cabinet (1981)

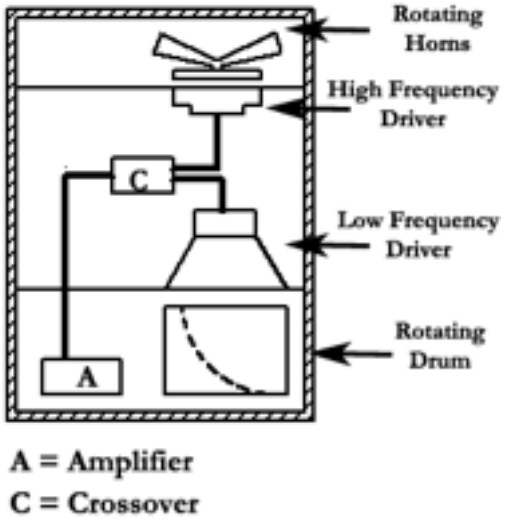

Fig.1 shows the internal components of a Leslie Speaker:

2. Problem Description

The main problem facing musicians, recording engineers and producers who want to record a Leslie is that the original Leslie speaker is now over 60 years old and becoming harder to find. Even subsequent later models are difficult to source, not to mention the cost associated with purchase, maintenance and transport of the extremely heavy and cumbersome cabinets.

Another problem is that if the Leslie was wanted to be used with different input source other than an organ for which it was designed for, the physical inputs would have to be modified to accommodate different input voltages. This adds another layer of complexity to an already growing list of potential difficulties.

An adjustable crossover is something that is also missing from the Original Leslie cabinet. If different sources of different frequency characteristics were wanted to be used, then the crossover might want to be adjusted to compensate for this.

All these factors combined prove that a great sounding and flexible DSP version of the Leslie cabinet would be an instant success.

3. Specifications

The specified ROTATRON plugin will be a faithful representation of the Original Leslie Speaker, with a few extra improvements for ultimate flexibility.

The improvements will include:
- Adjustable Crossover for use with different instruments
- Individual Rate and Depth controls for both speaker bands
- Mono Input, Stereo Output

The ROTATRON will also faithfully represent the original characteristics of the Leslie Speaker - It will have both Frequency Modulation (FM), which provides the and Amplitude Modulation (AM) for the rotating horns, as well as AM for the Rotating Drum, as shown in figure 2.

Amplitude Modulation is the change in the intensity of sound, dependent on the location of the horn in regard to the listener. As the horn is directional, the sound intensity will be at a maximum when it is directly facing the listener and at a minimum when facing away from the listener. This can be thought as a Tremolo effect

Frequency Modulation is the change in frequency in relation to the speed and direction of the horn. If the horn is rotating towards the listener, its speed will increase the frequency (higher pitch). As the horn is rotating away, the frequency will decrease (lower pitch). This is considered a vibrato sounding effect.

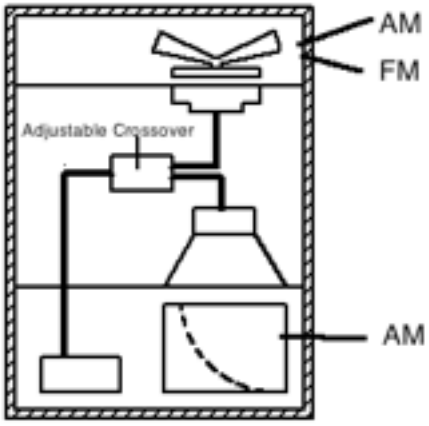

Fig 2 - AM and FM components of the Leslie

The ROTATRON will also be easy to use with an intuitive GUI which is not difficult to use. This is especially important so that all users (musicians, studio engineers and producers) will feel comfortable in using the ROTATRON

By being a stand-alone Audio Plugin for any DAW, the cost is minimised due to having no hardware manufacturing process involved.

4. Implementation

The function of the ROTATRON can be seen from the proposed GUI, which has all the controls needed to create a faithful Leslie representation, as shown in figure 3.

The GUI will be split into the two bands, which represent the two separate drivers of the Leslie Cabinet: The Rotating Horns will be the High band, while the Rotating Drum will be the Low Band.

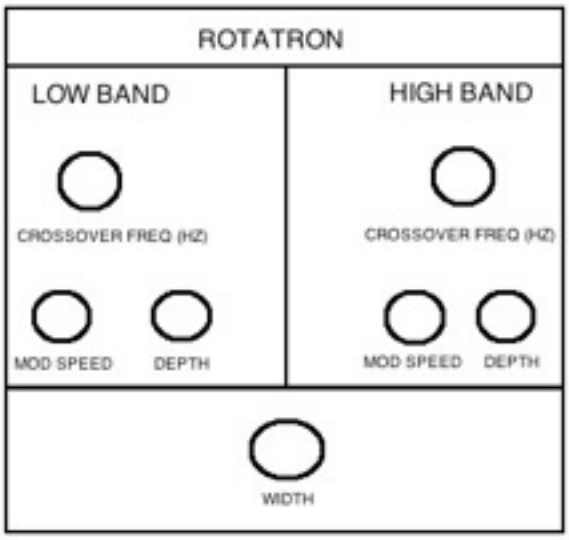

Fig 3 - GUI model of the ROTATRON

Explanation of Parameters for the High Band:

- Crossover Frequency: The user can select a frequency at which the input's high frequency content will be processed by the High band parameters. This is commonly referred to as the High Pass Cutoff Frequency, and is measured in Hz.

The range of values is suggested to be from 600 - 1000 Hz, depending on the input source frequency spectrum.

- Mod Speed: The rate at which the horns will spin - A low value means a slow rotation, while a high value means a fast spinning effect.

A modulation rate of around 2-5Hz is suggested for a natural sounding speed, but from 6-9Hz can be used for more experimental sounds.

- Depth: The difference between the amplitude of the signal. A low depth means the volume of the rotating horns will fluctuate slightly, while a higher depth value will mean that the volume will be similar to an on/off effect of a Tremolo.

A value of 0.3 is considered subtle, with a more swelling type effect would be a value of 0.9. The range can be from 0.1 - 0.3.

- Width: How wide the pitch is modulated. A low value means that the frequency spectrum changes very slowly, giving a narrow vibrato effect. A large value means that the sound is modulated by a large amount, giving a slightly more unrealistic frequency and time shift.

The recommended value for Width is 0.001s for a subtle effect, with anything above 0.005s considered slightly drastic.

Explanation of Parameters for the Low Band:

- Crossover Frequency: The user can select a frequency at which the input's low frequency content will be processed by the Low band parameters. This is commonly referred to as the Low Pass Cutoff Frequency, and is measured in Hz.

The suggested range of the Low band Crossover is 300-600 Hz. If values below 300 are used, there might be a spectral hole in the sound depending on the input. So something like a Bass guitar would have to be treated with caution.

- Mod Speed: The rate at which the rotating drum will spin - A low value means a slow rotation, while a high value means a fast spinning effect.

As the Mod speed is traditionally slower for the Low band, so it should always be 1 less than whatever value is set for the High band. However, if experimenting with different source inputs, this is less of a factor.

- Depth: The difference between the amplitude of the signal. A low depth means the volume of the rotating drum will fluctuate slightly, while a higher depth value will mean that the volume will be similar to an on/off effect of a Tremolo.

A recommended Depth value is again dependant on the input. For a bass heavier frequency input, the depth value should be lower (around 0.2) to prevent the Low band from masking the high band. If the input is more equal in terms of frequency spectrum,

then an value slightly lower than the High band is recommended.

5. Evaluation

In order to evaluate whether or not the ROTATRON is suitable for release can be decided by a couple of different methods. One method could be to have the resulting processed sound from the ROTATRON Matlab function compared to the same musical sample being played through a hardware Leslie speaker.

The other method would be to compare different parameters of the hardware Leslie Speaker, and deciding whether each of the parameters have the same effect on the sound as the ROTATRON.

The first method could be examined by having subjective A/B listening tests by a wide range of subjects. One group could be Leslie experts, the other group could contain Musicians familiar with the sound of a Leslie and the third could be a control group of non-musicians who are not familiar with the sound.

The results could be serve as a form of verifying whether or not the ROTATOR is a suitable replacement. If any of the test groups are satisfied with the sound, then it can be considered a small success. If all three find that the difference between the original Leslie and ROTATOR is very small or even prefer the sound and flexibility of the ROTATOR, then it can be seen as a signal to start sales of the commercial ROTATOR product.

The other method of comparing parameters between the original Leslie and the ROTATOR could be done in terms of audio analysis between the two. The first method would be preferred as it would be quicker and cheaper than spending much more time and money for Lab comparisons between specific functions. However, this could be a more scientifically approved method.

6. Conclusion

Overall, the ROTATOR is a sure return investment. Not only does it does it solve problems of the original Leslie Speaker, it will change the way the stated demographic will perceive digital representations of Analog hardware. With some fine tuning, it could prove revolutionary.

Acknowledgements:

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Code Sources:

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[1] - D. Leslie, Rotatable tremulant sound," US Patent 2 489 653, Nov, 1949.

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