

Improving the Behaviour of Ageing Bass Guitar Strings

Peter Möhringer

Faculty of Electrical Engineering
University of Applied Sciences
Fachhochschule Würzburg-Schweinfurt
D-97421 Schweinfurt, Ignaz-Schön-Str. 11
Germany
pmoehrin@fh-sw.de

Christian Krug

Faculty of Electrical Engineering
University of Applied Sciences
Fachhochschule Würzburg-Schweinfurt
D-97421 Schweinfurt, Ignaz-Schön-Str. 11
Germany
christian.krug@gmx.de

Abstract - Unfortunately, bass guitar strings continuously lose their typical dynamic characteristics during operation. The deterioration in sound is a result of dirt, stripped skin particles and acid deposits caused by picking the strings with fingers. So, to avoid decay in sound and performance, the set of strings has to be changed after being played for a rather short time. In the presented study, the typical behaviour of ageing bass strings was exemplarily tested and appropriate compensation methods for a prolongation of lifetime were applied and compared. Sound examples shall demonstrate already achieved results.

Key words:

digital signal processing, adaptive comb filters, time variant filtering

I. INTRODUCTION

Signal processing has been used in music instruments with electrical pickups for many years. Equalisers, echo and sustain generators and other sound machines creating distortion or wah wah effects are typical equipment of today's musicians. [1]

But the electronic equipment can offer by far more options to the user and a viable solution to reduce ageing effects of steel bass strings might be implied into the signal processing system. The aging effects are outlined in the following and some improvement will be announced. The focus is laid on spectrum equalisation and time variant filtering. A note adaptive algorithm completes the carried out tests. [2,3]

II. THE BEHAVIOUR OF BASS STRINGS

To gain information of the typical behaviour of new and already partly worn out bass strings, the pickup of a bass guitar was connected to a PC sound card and the signal was sampled with 22.050kHz and stored in a .wav type file. Step by step strings of different age and state were picked in a similar way and the results were compared to each other.

A. Time Domain

Fig. 1 shows a 20s record of the tone A1 (55Hz) for a new, and fig. 2 of a already longer played 'A' bass string.

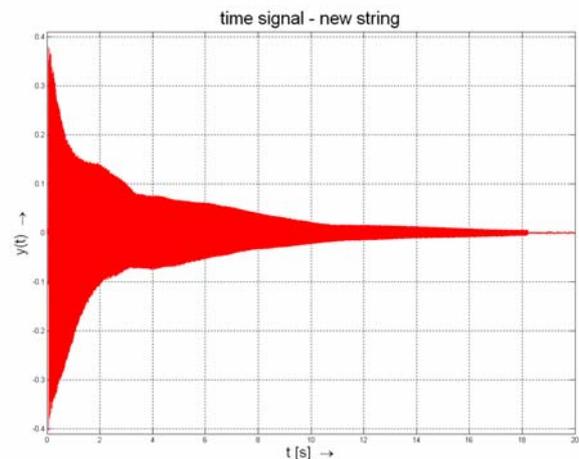


Fig. 1: Time signal of the new string

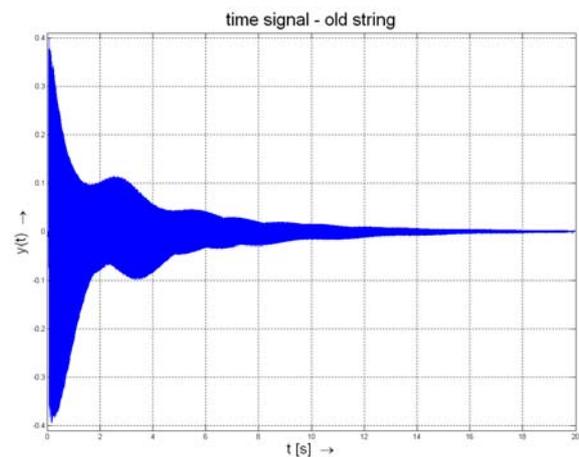


Fig. 2: Time signal of the old string

Obviously, the envelope of the time signals varies, but the sustain of both sounds is diminishing about the same amount.

To gain more and detailed insight into the time behaviour, the first samples of the response are zoomed and shown in fig. 3. But, as can be seen easily, the differences do not provide reliable information.

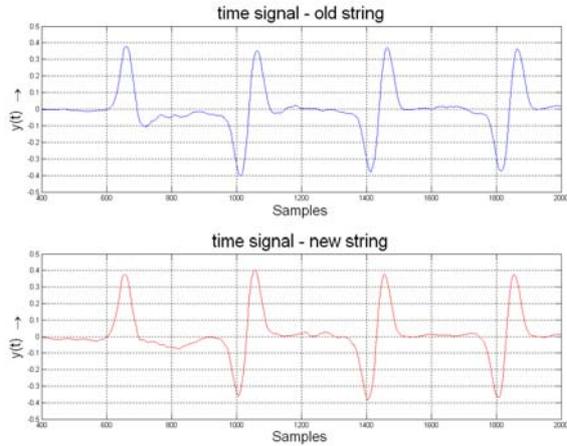


Fig. 3: Time signal, old and new string, zoomed (old - upper, new - lower)

B. Frequency Domain

As a next step, we will use Discrete Fourier Transform to check the frequency domain. The result of the transform applied to the whole signal of 20s of duration is plotted in fig. 4. Frequency axes limited to 2205Hz.

Although, there are differences in the frequency response, only a time invariant system is described by this way of transforming. Time varying effects during the oscillation of the string are not visible and thus do not give a measure for ageing.

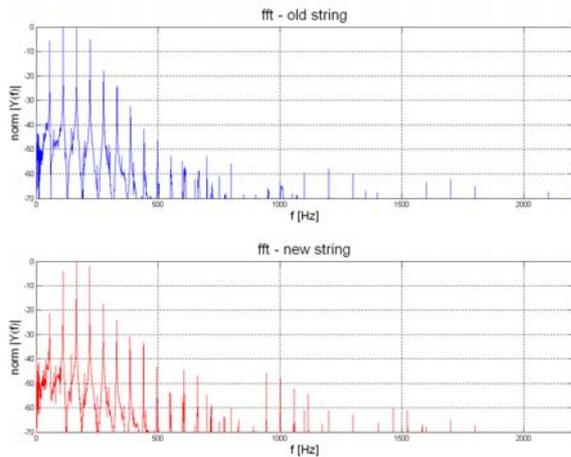


Fig. 4: Frequency response of whole signal (upper, old string, lower, new string)

To gain also time information we applied DFT on time slices. The 20s signal was cut into 222 time slices of 91ms duration and the DFT was computed step by step. (See table 1.) The resulting short time spectra, with frequency axes limited to 1408Hz is shown in fig. 5 and 6.

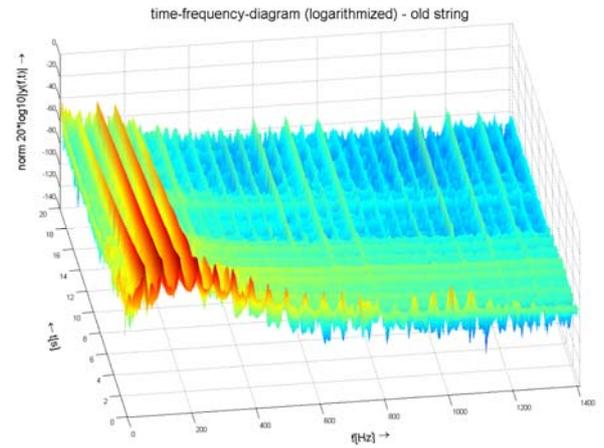


Fig. 5 Short time spectrum, old string

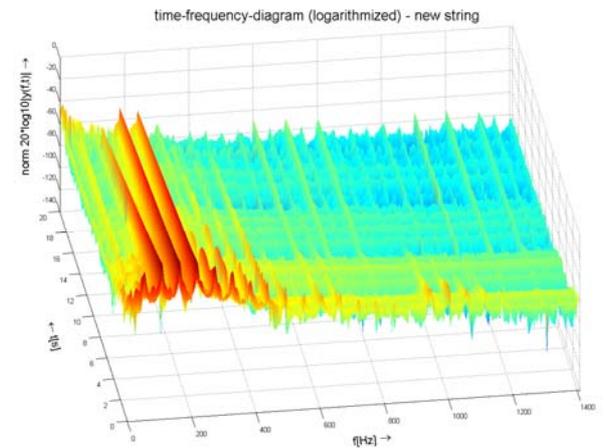


Fig. 6 Short time spectrum, new string

Time slices	Time slice length	Frequency resolution	Frequency max
222	91ms	11Hz	1408 Hz

Table 1: Parameters of the short time spectrum

Testing the performance of the fundamental frequency and the attenuation of the overtones shows differences in the envelopes. Obviously, the fundamental frequency 55Hz of the new string is declining much faster compared to the aged string, but higher overtones have a long sustain. Aged strings' overtones fade out faster. In fig. 7 red lines show the effects for the new string, the blue lines for the old strings, respectively.

attenuation of fundamental and overtones

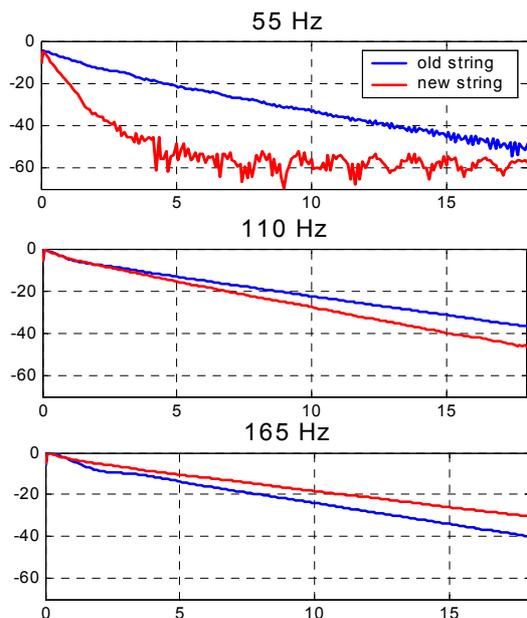


Fig. 7 Attenuation of fundamental and overtones

III. IMPROVING THE BEHAVIOUR

Strategies for improvement were tested, starting with an equalisation of the spectral difference, continuing with time varying filtering and as a third test, using an adaptive time varying system.

A. Measuring of the fundamental frequency

To apply an appropriate algorithm the current fundamental frequency has to be determined. A look on the signal of fig. 3 shows, that there is no simple sinusoidal oscillation, the overtones strongly influence the signal. So, only the application of autocorrelation function (AKF) yielded reliable results. The time signal and the fundamental frequency over time, measured by means of AKF, of a bass line from the song "Give it away", by Red Hot Chilly Peppers" are shown in fig. 8. To avoid undefined results in no, or low signal time spaces, a threshold is necessary.

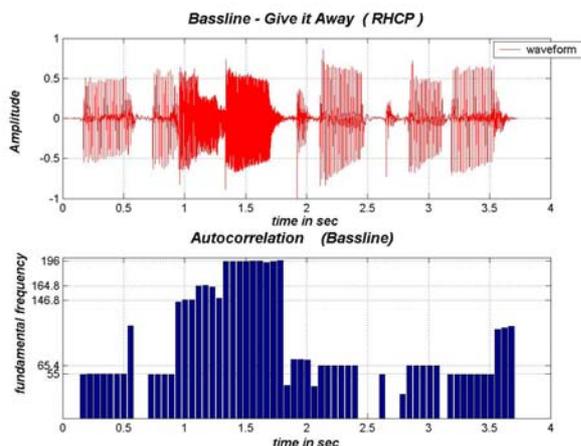


Fig. 8 AKF measured fundamental of bass line

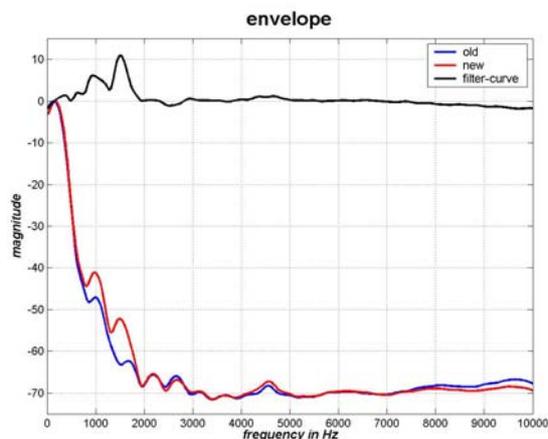


Fig. 9 Equalising the spectrum

B. Equalising the spectral differences

As a first and easy test, the envelopes of two different spectra of tune A1 were equalised. Fig. 9 shows the spectrum of tune A1: old in blue, new in red and the filter curve of the equaliser in black. Obviously the frequency range from 700Hz to 2kHz shows the greatest difference. The result is quite promising, but this method requires a very long delay to compute the spectrum. So, it seems only useful for offline operation and cannot be applied while playing life on stage.

C. Using a filter bank with time varying gain

The second tested algorithm is based on a linear phase filter bank with time varying gain of the channels. Fig. 10 shows the magnitude of the 6 channels in our test. To avoid loss in dynamic of the sound, the group delay of all channels is equal.

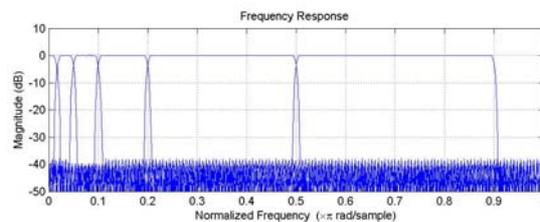


Fig. 10 Magnitude of the filter bank

The gain was determined by equalizing the typical energy amount in selected small time frequency intervals and has to be provided in a data base for every note. Fig. 11 shows the response for the tested note A1.

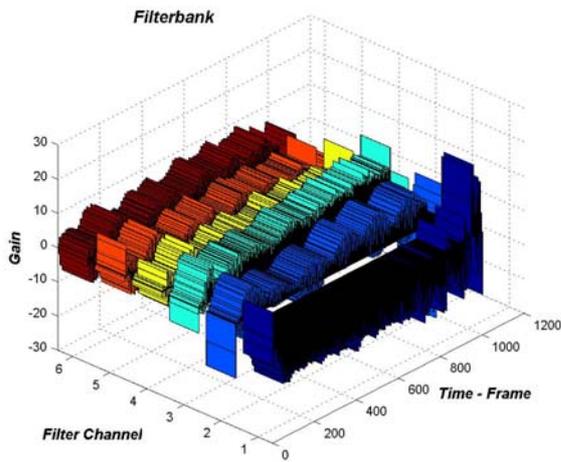


Fig. 11 Gain of the 6 channels varying in time

D. Using an adaptive comb filter with time varying frequency response

Adaptive comb filters separate fundamental and overtones from noise and other unwanted spectral influences. In our test, we adapt the maxima of the comb filter fitting with the frequency of the fundamental and the overtones from note to note. The current note is determined by means of AKF.

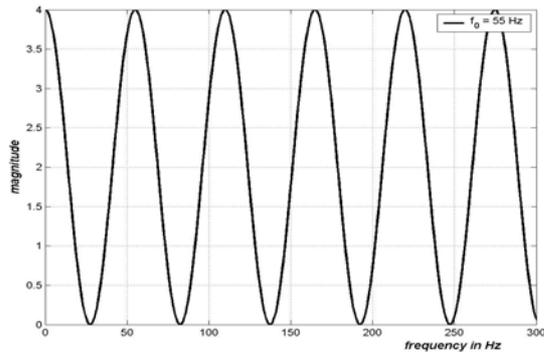


Fig. 12 Magnitude response of the comb filter adapted to A1 (zoomed detail)

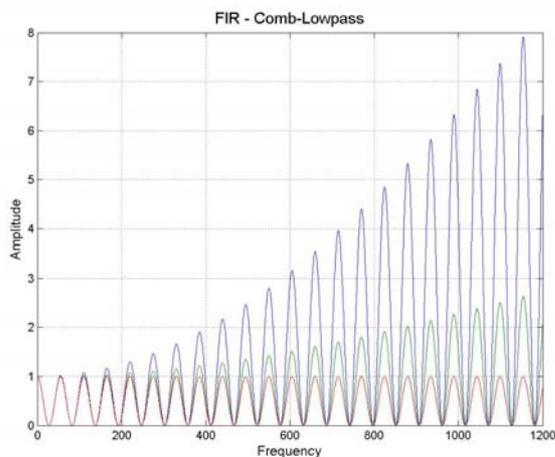


Fig. 13 Amplitude of the cascaded comb and different equalising filters

Equalisation is then realised by frequency dependently varying the gain of the filter. Fig. 12 shows the typical frequency response of a comb filter and fig. 13 the combination of comb filter and an equalising filter, adaptively adjustable in gain. Sound tests result in improved and clear highs accompanied by less noise. The smoother start after the picking is due to the filtering. See fig. 14.

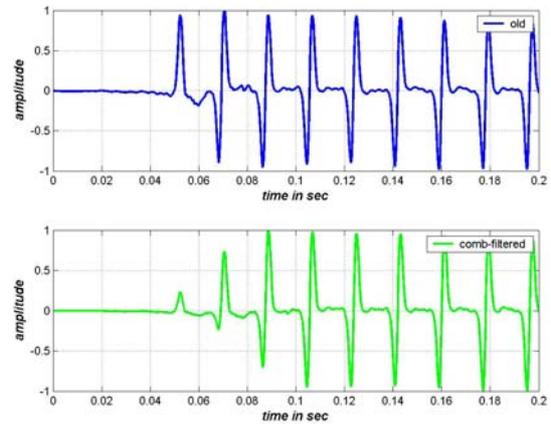


Fig. 14 Signal before and after being filtered

IV. CONCLUSION

Ageing of bass strings can partly be reduced by applying an appropriate equalising strategy. The simple method of only taking into account the spectral difference is probably no solution for life performing. But adaptive methods, depending on the played note and its duration can result in valuable improvement of the behaviour of ageing bass strings' lifetime. Further tests of equalising filters, e. g. also IIR filtering, and the elaboration of a sufficient data base, may improve the overall ability and should in the future lead to a signal processor based test system for life operation.

V. REFERENCES

- [1] Pieper, F.: "Das Effekte Praxisbuch", GC Carstensen Verlag 2004
- [2] Möhringer, P., Krug, Ch.: "Analysis of the Behaviour of Ageing Bass Guitar Strings", Proc. of XXIVth Int. Kandó Conference 2008
- [3] Krug, Christian: „Untersuchung von gealterten Bass-Saiten“, Diploma Thesis, UoAS, FH-WS Würzburg-Schweinfurt 2008

VI. THE AUTHORS

Prof. Dr.-Ing. Peter Möhringer, University of Applied Sciences, Fachhochschule Würzburg-Schweinfurt, is head of the communication systems branch of the faculty of electrical engineering.

Cand. Ing. Christian Krug, diploma student of University of Applied Sciences, Fachhochschule Würzburg-Schweinfurt FHWS 2008