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Electronic Music Effect Generator with FPAA

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Abstract—The timbre of many musical instruments can be modified and coloured with electronic effects. In instruments where the sound produced is essentially sinusoidal or near-sinusoidal, it is common to alter the timbre of these instruments electronically. Two approaches to this are now used; signal modification or frequency domain spectrum modification. Of course, the relationship between the two can be described by Fourier transforms.

Most commonly, effects equipment is used for guitar, electronic guitar. With this article we describe some approaches to this and give recommendations for its implementation with FPAA.

I. Introduction, Vismajor in the Frequently used Method

Most orchestral distortion systems use a comparator (Fig. 1). In this evening, some excess voltage of the sinusoidal signal is squared, producing a 'fundamental' sound with significant harmonic content [1][2]. This is a simple procedure, but setting the right level of comparator is problematic [3][4]. At too low a value, the higher-intensity fundamental harmonic relay is reduced, while at a high comparator reference value, small signal levels are not distorted (Fig. 2, Fig. 3, Fig. 4, Fig. 5). Thus, the "tonality" of the distortion value, the harmonic content of the distorted signal, is highly volume dependent (Fig. 6, Fig. 7, Fig. 8).

In the following, we show some theoretical and practical solutions to overcome this.

II. Comparison Signal Level Setting with Average Definition

Some methods are available for determining the comparator signal level as described above [3][5] [6]. Perhaps the most

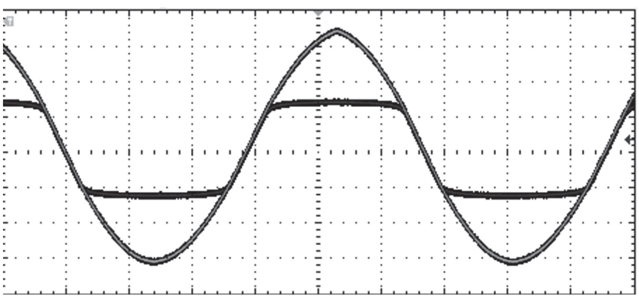

Fig. 1. Sinusoidal signal and distorted signal produced by a parallel diode limiter circuit.

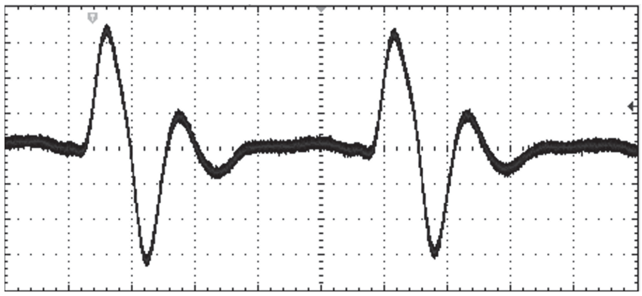

Fig. 2. Time function of two consecutive "E" notes (~ 370*Hz*) strummed on guitar

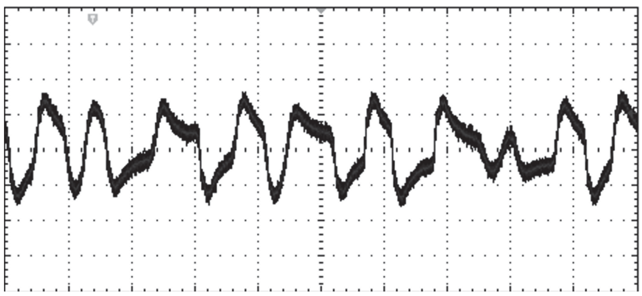

Fig. 3. Time function of the distorted signal of two consecutive "E" notes (~ 370*Hz*) strummed on guitar

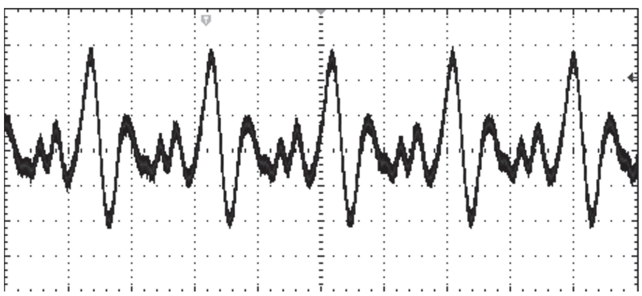

Fig. 4. Continuously strummed "E" sound on guitar..

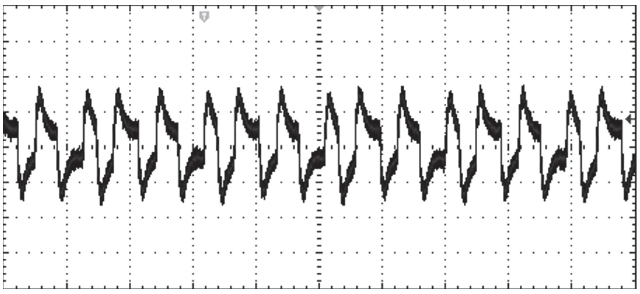

Fig. 5. Distorted sign of the ”E” sound continuously strummed on the guitar..

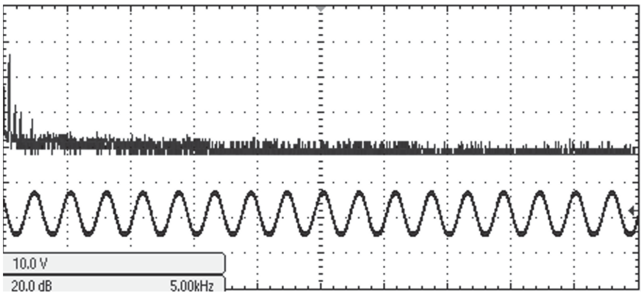

Fig. 6. Normal ”a” sound 440Hz near sine wave (bottom) and its spectrum (top).

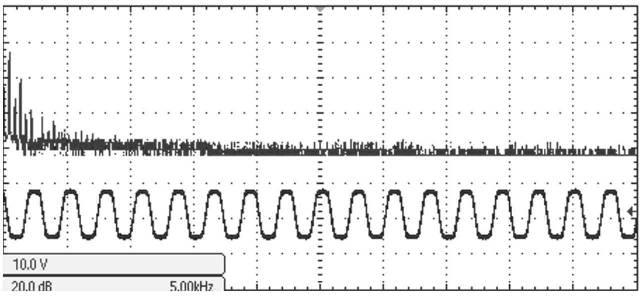

Fig. 7. Normal ”a” sound 440Hz distorted sine wave (bottom) and its spectrum (top).

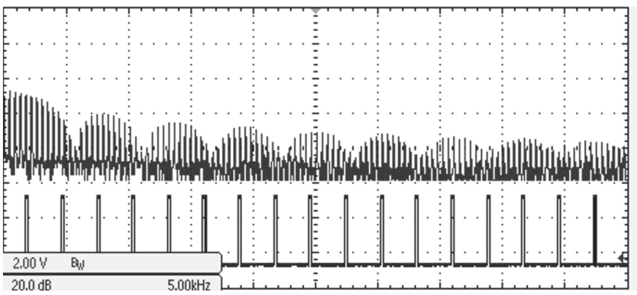

Fig. 8. Normal ”a” sound with 440Hz highly distorted signal (bottom) and spectrum (top).

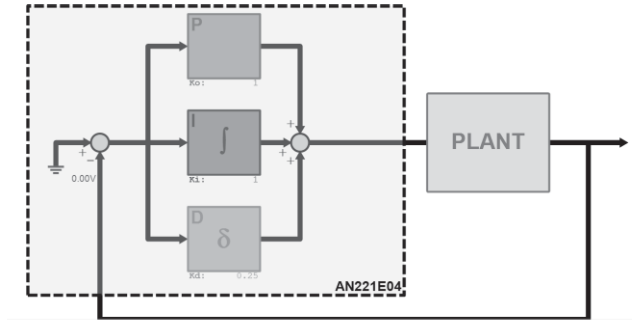

Fig. 9. PID configuration application in the FPAA development environment..

useful is to calculate the average value of the input signal and set the current comparator value as a function of this. This method requires a procedure where the averaging is integrating, proportional and fast enough. The natural answer to this is a PID-type signal conditioning unit (Fig.9) [7][8][9]. The use of the PID algorithm guarantees a sufficiently good averaging, proportional gain/attenuation and a sufficiently fast result [10][11].

III. Solution Using FPAA Hybrid Cell

In previous articles, we have analysed in detail the possibilities offered by FPAA tools, including flexible reconfiguration [12][13][14][15][16][17]. We have also pointed out in these articles that the special relationship between a microcontroller and an FPAA device offers additional possibilities, also as robust electronic circuit solutions. We have referred to this established special connection arrangement as a hybrid controller, or in other contexts as an embedded hybrid controller [18][19][20].

Fig.10 shows the structure of the hybrid cell proposed earlier.

The cell has A_{in} analog and D_{in} digital inputs and A_{out} analog and D_{out} digital outputs [21][22][5][23][24].

The internal topology (n) of the (field) programmable analog

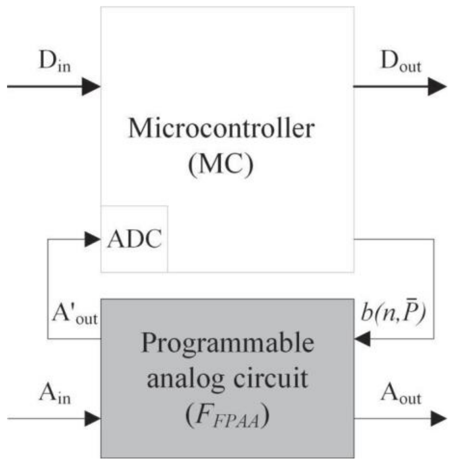

Fig. 10. Interactive connection of microcontroller and FPAA circuit as a hybrid cell.

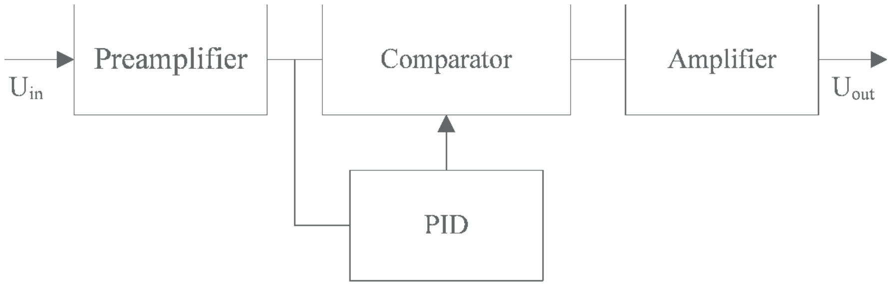

Fig. 11. Block scheme for Distortion, by continuously adjusting the average value of the music signal.

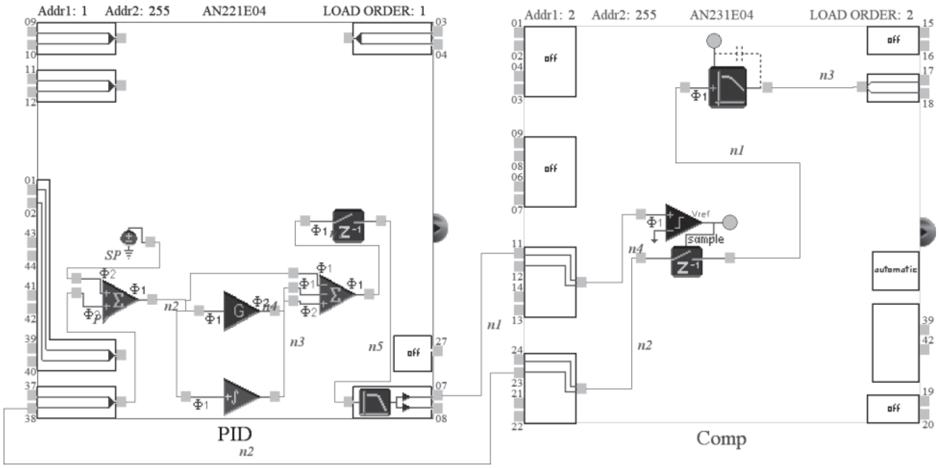

Fig. 12. A bias based on continuous variation of the mean value implemented in two FPAAs. The left circuit contains the PID unit.

array (F_{FPAA}) and the vector of parameters ($\bar{P}$) of the components are expressed by the microcontroller (MC) as a binary string through the interface $b(n, \bar{P})$ [25][26].

In this case, the connection between A'_{out} and the ADC input of the microcontroller generates the firmware trigger that initiates the reconfiguration .

IV. Implementation of PID Averaging Distortion using FPAA

Fig. 9 also shows that a common application for programmable circuits is the design of a PID circuit. For this purpose, the application (Anadigm) provides a complete design environment, including simulation and the parameterized PID circuit itself, which can be loaded into the FPAA [27][28][29]. In this case, it is also true that the implementation options already influence the design of the architecture at the planning stage. Fig.11 shows a block diagram of the proposed distortion device. The input signal (U_{in}) is fed to a signal level matching amplifier. Its output is the PID averager and the signal trimming comparator. The output of the PID unit continuously adjusts the comparator level as a function of the input signal. The distorted signal is output after a driver amplifier (U_{out})[30][31][32].

The implementation of the proposed architecture is shown in Fig.12.In the figure, the FPAA on the left (AN221E04) contains the PID circuit (Figure 9), while the FPAA on the right (AN223E04) contains the comparator and an amplifier that low-pass conditions the output signal. The music signal goes to wire $n2$ ($AN221E04_{38}$), while the distorted signal is available on wire $n3$ ($AN223E04_{17,18}$) [33][34][35].

The multifunctionality of the distortion circuit and the wider musical experience offered by the PID parameters depend on the intensity of the input signal, the fundamental harmonics of its frequency. The previously proposed hybrid cell is an excellent choice for arrow-like interactivity [36][37][38].

V. Distortion using a Delay Line

We could make a really good quality distortion device if we could use some kind of predictive technique. Of course, this is not possible, because - fortunately - music, the musical signal, is not deterministic.

If the music signal is successfully delayed, we can ”predict” the delayed signal from the current (prompt) signal.In live music, this method has very limited application, as the delay affects the musician’s habitus. An important criterion, therefore, is to achieve a small delay (Fig. 13). If this is achieved, the comparator cut-off level should be set at or before the maximum (inflection points) of the prompt signal [39][40].

The figure shows a block diagram of the proposed equipment. The U_{in} signal is fed into a preamplifier. Its output is the

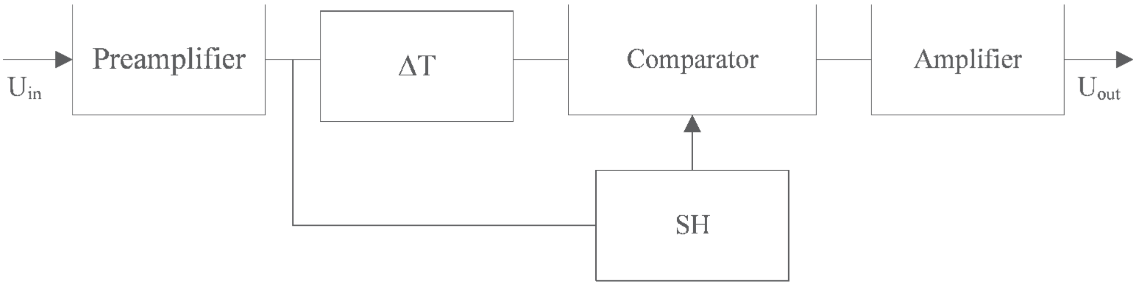

Fig. 13. Block scheme for delay-based ”predictive” distortion.

ΔT all-pass ”filter” as a delay unit. This of course achieves the minimum possible delay, but still the required greatness. The maximum of the music signal is determined using a sample-and-hold (*SH*) circuit [41][42]. The maximum search with the sample-hold (*SH*) circuit is a traditional engineering approach; if the value of the sampled signal (u_{SH}) is compared to the value of the current signal (u_t) and ut is greater than u_{SH} , then we are not yet at the maximum. If $u_t = u_{SH}$, then we have reached the maximum value, i.e. we have reached the inversion point of u_t.
Fig. 14 shows the coupling of a delay line distorter implemented in an FPAA.

VI. Conclusions

Both of the two methods presented can be implemented in an FPAA circuit. Additional options for implementation include a signal algorithm supported by circuit robustness, and an embedded microcontroller as an operational support method or device.
In the current phase of development, we have focused on possible circuit solutions that can be implemented in FPAA, or further possibilities can be developed with an embedded hybrid controller.

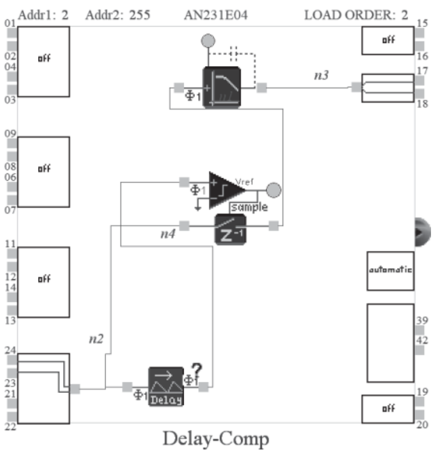

Fig. 14. Theoretical implementation of delay line distortion in FPAA circuit.

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