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# The Wireless Electric Guitar with Digitally Integrated Effector

Chun-Tang Chao, Kuo-An Li, and Nopadon Maneetien

**Abstract** This chapter presents the design and implementation of a wireless electric guitar with digitally integrated effector. Wireless audio modules are first employed so that electric guitar players no longer have to worry about stumbling on the stage. Furthermore, in a traditional analog way, electric guitar players may face many different kinds of effectors, such as distortion, flanger, and reverberation. It is hard for players to control them by pedals. The digitally integrated effectors are proposed and implemented by DE2-70 Multimedia Development Board. Finally, a little radio transmitter with multiple keys is equipped on the electric guitar such that the players can easily select the desired audio effect.

**Keywords** Wireless electric guitar • Effectors • DE2-70

## 1 Introduction

Compared to the classical guitar and acoustic guitar, electric guitar with powerful sound attracts a lot of young music fans [1]. The reason why electric guitar can capture the tone played is because of the magnetic pickup installed in it. The people familiar with the electric guitar often need to purchase many effects to make the sound effect more vivid. Figure 1 shows some single electric guitar effects.

Due to the inconvenience of the single effect, there is the advent of integrated effect, shown in Fig. 2. But it is bulky and must be controlled by pedal or button. For the guitar players, it is still not easy for them to do real-time manipulation. In this paper, we hope to improve these missing by applying modern digital technology.

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Fig. 1 Single electric guitar effects, delay, flanger, and echo (left to right)



Fig. 2 Electric guitar analog integrated effects

Currently, only few researches have been on this topic [2]. On the other hand, there have been a lot of international researches on guitar effects [3–8]. This paper tries to use Altera DE2-70 to finish wireless electric guitar with integrated digital effects.

## 2 System Description

The FPGA-based digital integrated system will be first introduced. Then some topics such as wireless audio transmission, radio code transmission, and digitally integrated effectors will be described in subsections.

### 2.1 FPGA-Based Digital Integrated System

Figure 3 shows the wireless electric guitar system blocks. The Altera DE2-70 board is used to finish to DSP (digital signal processing), ADC, and DAC functions.

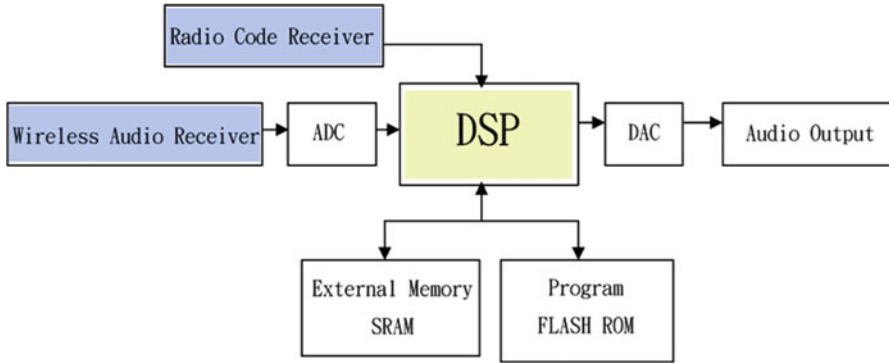


Fig. 3 The wireless electric guitar system blocks



Fig. 4 The 2.4 GHz wireless audio transmitter

## 2.2 Wireless Audio Transmission

To make the electric guitar wireless, we should eliminate the wire from guitar to speaker in the first step. In order to accelerate the realization of the creative concept in this paper, we directly use a commercially available Waveconn 2.4 GHz wireless stereo headphone and modify it. Figure 4 shows the 2.4 GHz wireless audio transmitter.

The corresponding and modified 2.4 GHz wireless audio receiver is shown in Fig. 5.

Before the receiver in Fig. 5 is connected to the DE2-70, the proposed pre-amplifier and anti-aliasing filter circuit is required (Fig. 6). It is worth mentioning that the operating amplifier design uses single power [10, 11].

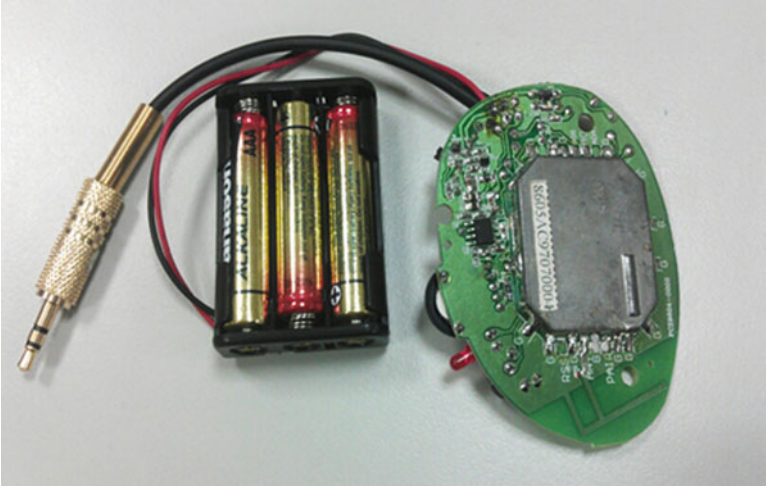


Fig. 5 The 2.4 GHz wireless audio receiver

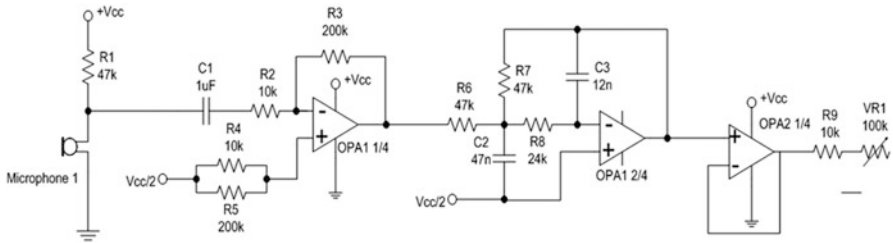


Fig. 6 Preamplifier and anti-aliasing filter circuit

### 2.3 Radio Code Transmission

To save development time, the applied radio code transmitter and receiver in Fig. 7 are also commercially available.

### 2.4 Digitally Integrated Effectors

In the subsection, some effects in the proposed system are discussed.

#### 2.4.1 Flange Effect

Flange effect is like chorus, the difference is that the delay for flange is about 0–35 ms, while the delay for chorus is about 35–50 ms. To combine both flange and

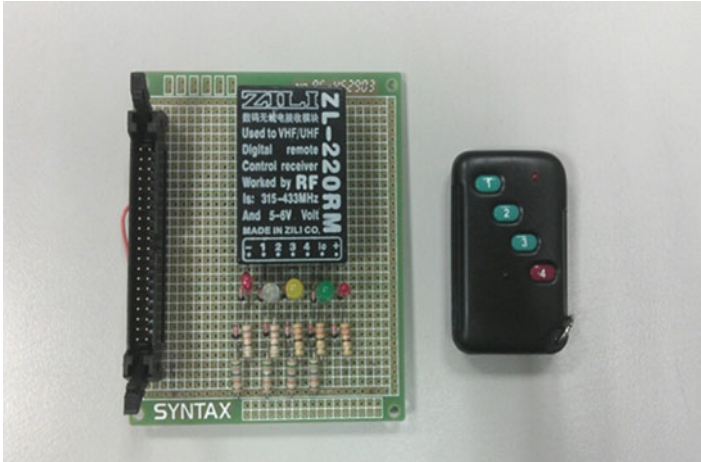


Fig. 7 Radio code transmitter and receiver (right and left)

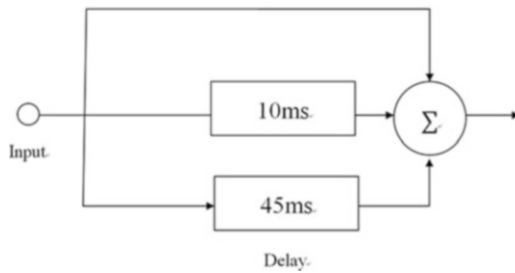


Fig. 8 Block diagram of Flange effect

chorus effect, we try to finish the system difference equation in (1) and its schematic diagram is shown in Fig. 8.

$$y[n] = x[n] + x[n - 128] + x[n - 768] \tag{1}$$

### 2.4.2 Reverberation Effect

This effect is similar to echo effect. The filter in (2) can produce “onefold echo” for the given input signal. If the sample frequency  $f_s$  is 16 kHz, then the time difference between the input and the echo will be about 0.1 s:

$$y[n] = x[n] + 0.8 * x[n - 1,600] \tag{2}$$

To produce a more realistic “multiple-fold” echo [13], (2) can be modified as (3). The original FIR type in (2) becomes IIR type in (3):

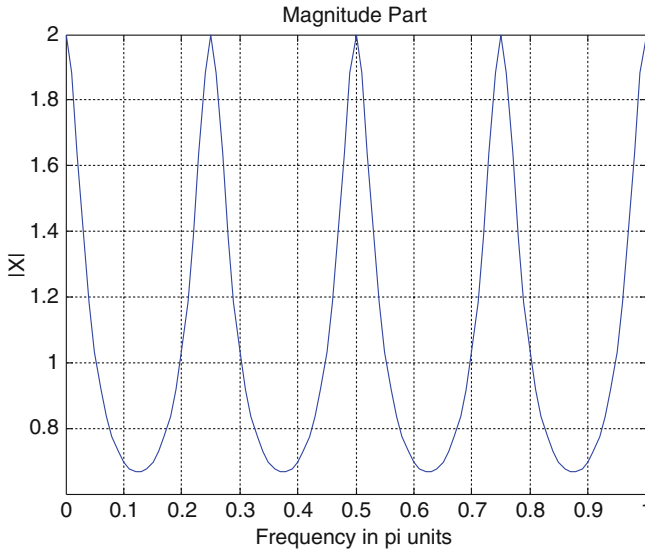


Fig. 9 Frequency gain response of digital comb filter

$$y[n] = x[n] + 0.8 * y[n - 1, 600] \tag{3}$$

The resulting Z transfer function is shown in (4), a so-called comb filter:

$$H(z) = \frac{1}{1 - 0.8z^{-1,600}} \tag{4}$$

Figure 9 shows a frequency gain response of digital comb filter with 8 time delay units.

To make the reverberation effect more apparent in software simulation, the echo effect in (2), (3) and (4) is modified from 0.1 to 0.5 s, and the feedback gain in (2), (3) and (4) is modified from 0.8 to 0.6. A 0.6 s short music is used as input, and the resulting output is shown in Fig. 10 in Matlab simulation.

### 2.4.3 Distortion Effect

When a sinusoid signal is taken as input of a clipping circuit, a severe distortion will occur and the resulting output is like a square wave. For auditory effect, it makes the original soft sound become rude. This sound effect can be thought as the most important one for some electric guitar players.

Before writing FPGA programs, the Matlab simulation can be applied to verify the distortion function. Figure 11a shows an input signal with hybrid frequency of 100 and 200 Hz; Fig. 11b is the resulting output.



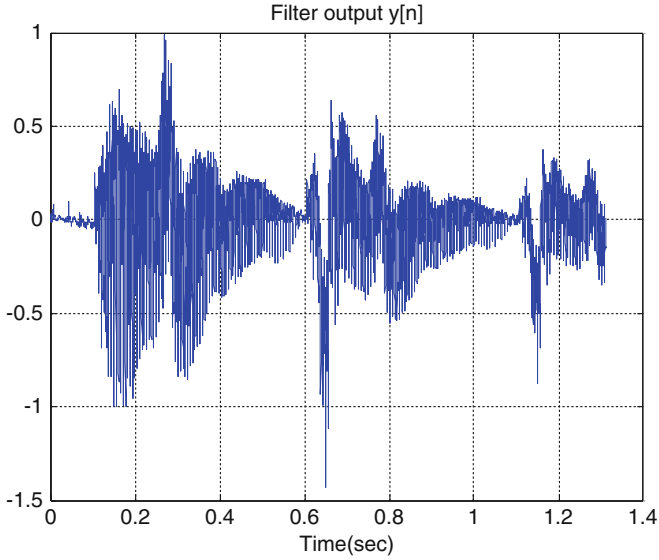


Fig. 10 Short music output by the reverberation effect

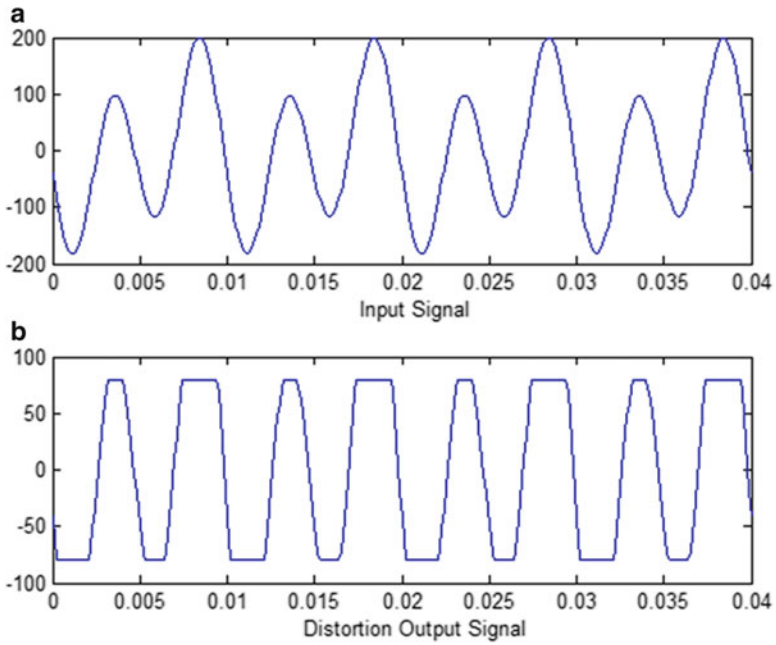


Fig. 11 The I/O of distortion effect

**Fig. 12** The wireless electric guitar with digitally integrated effector



Figure 12 shows the implementation of the wireless electric guitar with digitally integrated effector. In the electric guitar body, there are wireless audio transmitter and radio code transmitter. On the other hand, the FPGA DE2-70 is connected to wireless audio receiver and radio code receiver.

### 3 Conclusions

This paper has implemented a wireless electric guitar with digitally integrated effectors. First, the wireless audio modules are employed to transmit electric guitar music. Secondly, the digitally integrated effectors are presented so that electric

guitar players do not need to face messy wires and many different kinds of effectors, such as distortion, flanger, and reverberation. The DE2-70 board is applied as the core processor. Finally, to make the electric guitar players select the desired audio effect in an easier and quicker way, a small radio code transmitter with keypads is mounted on the edge of electric guitar. Based on the proposed prototype system, the integrated digital effector with more practical effectors will be investigated in the future.

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