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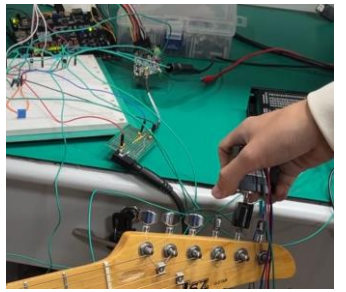
Guitar Automatic Tuner using AMD Spartan7

OpenHW2023

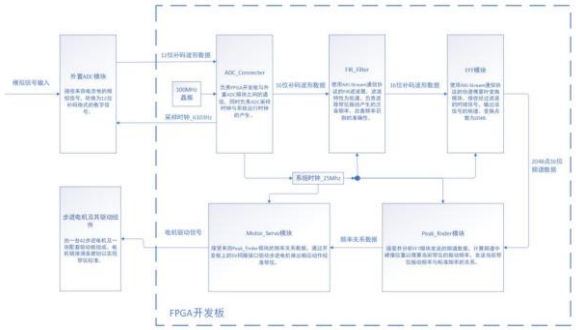
AMD



On board test by AMD Spartan 7

INTRODUCTION

This work is a guitar automatic tuner based on FPGA, and the overall workflow of the device is as follows:
(1) The analog signal generated by the guitar is picked up by the pickup and input into an external ADC module for sampling (sampling frequency of 6103Hz), which is then converted into a digital signal and output to the ADC inside the development board_ Connector module.
(2) The sampled digital signal is filtered through a FIR low-pass filter and output to the FFT module for fast Fourier transform (with 2048 transformation points) before entering Peak_ The Finder module performs peak searching to calculate the vibration frequency of the current string.
(3) Peak_ The Finder module outputs the relationship between the current frequency and the target frequency of the strings to the Motor_ Servo module, connected to the tuning knob of the guitar by the motor, rotates in the corresponding direction to achieve tuning.
(4) Return to step (1) and repeat the sampling until the strings are adjusted to the target frequency.



Overall Block Diagram and Introduction to Each Module

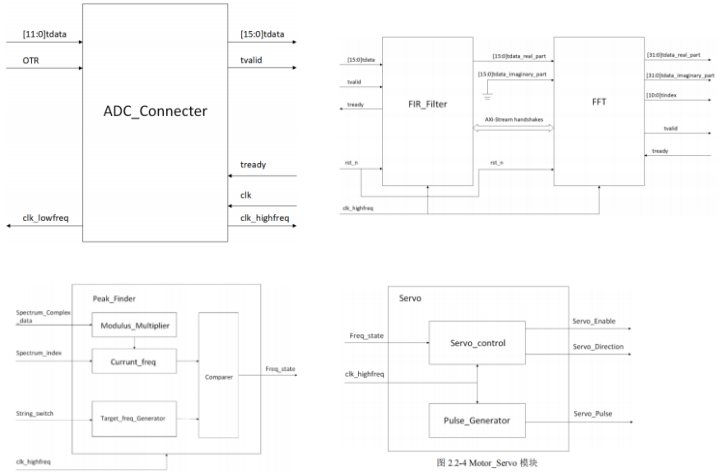


图 2.2-4 Motor_Servo 模块

Display of key modules

ADC_ Connector module is responsible for communication between the FPGA development board and the external ADC module, as well as generating the ADC sampling clock and system operating clock.

FIR_Filter module is a finite impulse response filter with low-pass characteristics, responsible for low-pass filtering the sampled data collected by the ADC to reduce the impact of harmonics generated by string vibration.

FFT module is responsible for performing Fourier transform on the filtered data to obtain its spectrum.

Peak_Finder module is responsible for receiving and analyzing spectral data.

CREATIVE DESING

RESULT

After testing, **the performance parameters of the guitar automatic tuner** are as follows:

(1) Calibration range: 40Hz (E0)~400Hz (G2)

(2) Pronunciation accuracy: ± 0.07 cent (± 3Hz)

(3) Average tuning time: approximately 11 seconds

Scalability

(1) At present, the rotation frequency of the motor is fixed, and the tuning time depends entirely on the frequency difference with the target pitch. In the future, it can be optimized to have a faster rotation speed as the difference between the target pitch increases, and a slower rotation speed when approaching the target frequency to accelerate tuning efficiency.
(2) The human-machine interaction and user interface of the product can be increased, such as adding a display screen design graphical interface to display real-time parameters such as the actual frequency and target frequency of the strings, tuning status, etc., to achieve more friendly and personalized tuning functions.
(3) You can add support for special tuning, set the corresponding sound names for different strings, and add memory to store different special tuning presets, making tuning more flexible and convenient.