

High Speed and Dynamic Switching Type Signal Generation on FPGA for Emulating the Test Signals for Navigation Receivers

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ABSTRACT

Playing an important role in navigation test, radio navigation generator is widely used in the people/military plane. But traditional equipment composed of analog circuit presents low accuracy and poor reliability. A new kind of digital navigation signal generator is designed in this paper. It receives data and commands from PC by MicroBlaze embedded soft processor of Xilinx company and demodulates information to control FPGA load different softwares to generate various navigation signals, which fully meets general radio navigation system test technical requirements by giving full play to the system hardware and software advantages and fulfilling design targets such as the accuracy, flexibility and expansibility. Therefore, providing a new idea for radio navigation system design and test, this generator can be widely applied to debugging use on people/military plane radio navigation.

Keyword's— Navigation, Receiver, Micro blaze, Xilinx.

I. INTRODUCTION

In modern aviation, navigation is an important technology. Using radio navigation technology to carrier plane in whole (or part of) process of sailing is called radio navigation. So far, equipped in almost all the military and civil airports, radio navigation system is the most widely used navigation devices in aviation. At present, radio navigation still has priority in short-range navigation of civilian and military aviation in our country. Also, due to the imperfect landing system device in the existing aircraft, radio navigation system is of vital importance in ensuring safety in plane's homing and approaching. In the actual navigation test, to simulate the rf signal of combined antenna in radio navigation, various signal generators are often designed to satisfy performance of navigation system and meet technical requirements. Meanwhile, the signal generator must

adjust signal types, parameters and work modes timely according to the navigation system requirements. Therefore, signal generator must have the feature that signal can be generated flexibly, parameters change quickly, signal spectrum stay stabilized, and the system is reliable, etc. Fundamentally, characteristics of signal patterns and real-time variability are mainly embodied in signal generation technology. Taking this as the background, for optimizing the system hardware and software resources, improving the processing speed, achieving the re configurability, this system adopts Micro Blaze soft processor as the control core of generator communicating command with PC and controlling FPGA load different software's to synthesize various navigation signals, which can satisfy each requirement in actual application of testing and debugging on navigation.

II. PROPOSED SYSTEM

In modern aviation, navigation is an important technology. So far, equipped in almost all the military and civil airports, radio navigation system is the most widely used navigation devices in aviation. At present, radio navigation still has priority in short-range navigation of civilian and military aviation in our country. Also, due to the imperfect landing system device in the existing aircraft, radio navigation system is of vital importance in ensuring safety in Plane's homing and approaching.

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change quickly, signal spectrum stay stabilized, and the system is reliable, etc.

The proposed system adopts MicroBlaze soft processor as the control core of generator to communicating command with PC. which can satisfy each requirement in actual application of testing and debugging on navigation. The important role in navigation test, radio navigation generator is widely used in the people/military plane. But traditional equipment composed of analog circuit Presents low accuracy and poor reliability. A new kind of digital navigation signal generator is designed. It receives data and commands from PC by MicroBlaze embedded soft processor of Xilinx Company and demodulates information to control FPGA load different softwares to generate various navigation signals, which fully meets general radio navigation system test technical requirements by giving full play to the system hardware and software advantages and fulfilling design targets such as the accuracy, flexibility and expansibility. Therefore, providing a new idea for radio navigation system. this generator can be Widely applied to debugging use on people/military plane radio navigation.

II. DESIGN SCHEME OF DIGITAL SIGNAL GENERATOR OF RADIO NAVIGATION

According to different technical requirements of navigation, the generated signal is basically formed by the carrier signal, low frequency modulated signal and audio modulated signal. Therefore, in this scheme, the signal generator adopts direct digital frequency synthesizer (DDS) technology to design precise clock reference source, word length of frequency and phase accumulator and sine function table to generate the modulated sine signal whose frequency variation scope, step length change and precision meet the acquires in overall design. Large-scaled FPGA is used in this system to realize accurate DDS, ADC converter is used to convert the external signal to be modulated by carrier signal, and the soft embedded processor MicroBlaze communicates with PC by RS422/232 as the control core, figure 1 is the overall scheme of digital signal generator of radio navigation. The control software of PC wrote in VC6.0 communicates with the generator through RS422/232 is in charge of transmitting control command to set frequency, azimuth angle, channel, working mode and other parameters of navigation signal and receiving status and data of the generator after every change. In this system, as a master unit MicroBlaze sends parameters to FPGA

after demodulating data from PC while FPGA generates accurate navigation signal to high-speed DAC converter as the ground floor synthesis unit. Meanwhile, multiple clock signals used in the system are generated in phase lock logic part of FPGA from external oscillator.

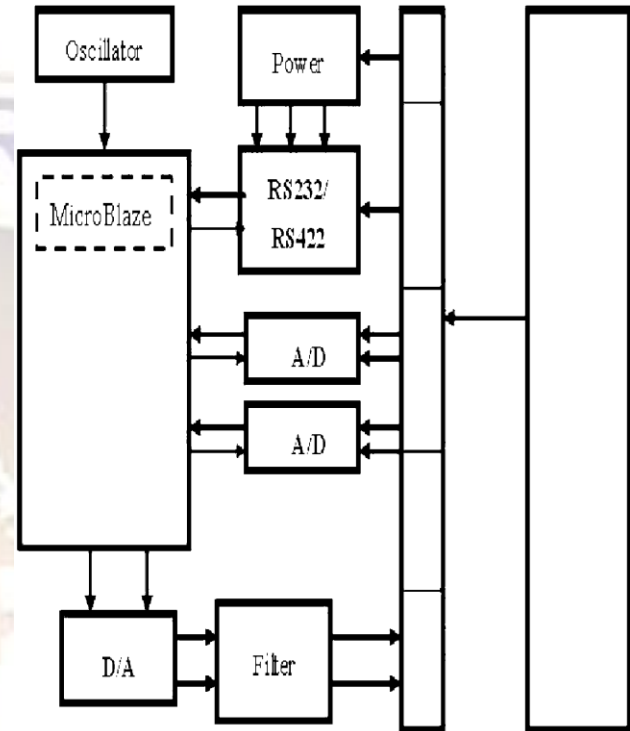


Figure1: Overall scheme of digital signal generator of radio navigation

III. REALIZATION OF DIGITAL SIGNAL GENERATOR OF RADIO NAVIGATION BASED ON MICRO BLAZE

A. Hardware platform

Xilinx XC2V1000 of Virtex - II platform is adopted in this system which has 40 dedicated multiplier blocks, up to 93,184 look-up tables(LUTs) or cascadable 16-bit shift registers, 3 Mb of dual-port RAM in 18 k bit block Select RAM resources and up to 1.5 Mb of distributed Select RAM resources and clocks up to 420MHz internal, presenting a strong computing ability and high speed data throughput capacity. Also an in-system programmable configuration PROM XCF04SV020C is used for FPGA configuration in this system. The MicroBlaze embedded processor soft core is a reduced instruction set computer (RISC) optimized for implementation in Xilinx FPGAs.

It is highly configurable, allowing users to select a specific set of functionality required by designs to build their own hardware platform. Fast Simplex Link (FSL) bus is a uni-directional point-to-point channel bus used to perform fast communication between any two design elements on the FPGA when implementing an interface to the FSL bus. First create a hardware system whose core is MicroBlaze under the integrated environment of XPS using Base System Builder (BSB) wizard, then follow the guide of EDK to add a peripheral of system with UART IP core connected by MicroBlaze FSL bus, use the Platform Generator to generate embedded system's net list document (.NGC) based on Microprocessor Hardware Specification (.MHS), and finally use the synthesized tool XST to constitute the whole hardware platform of the system.

ADC converter is mainly used for acquiring external low frequency signal. AD9218 with dual 10-bit channels of ADI company is selected in this system which works under 2.7V-3.6V and operates up to 105MSPS conversion rate. DAC converter is mainly used for generating rf modulated signal. AD9760 with single 10-bit channel of ADI company supporting update rates up to 125MSPS is chosen in this system, whose single-supply ranges from 2.7V to 5.5V.

B. Software Design

2.2.1 Design of PC Software Main task of PC software is to generate control command for frequency, azimuth angle, work mode, channel selection and other information which can be distinguished by command head and transmitted by RS422/232 to signal generator for the corresponding digital navigation signal.

2.2.2 Design of FPGA processing modules

Main task of FPGA hardware is to produce precise Modulated rf modulated signal. The tasks are included as follows:

- 1) Receiving carrier frequency, azimuth angle and other relevant control commands from MicroBlaze;
- 2) Generating audio signal, carrier signal and azimuth angle signal;
- 3) Receiving two-channel low frequency signal from ADC converter;
- 4) Synthesizing navigation signal and transmitting it to DAC converter according to the command from PC. The processing modules of FPGA are shown in figure 2.

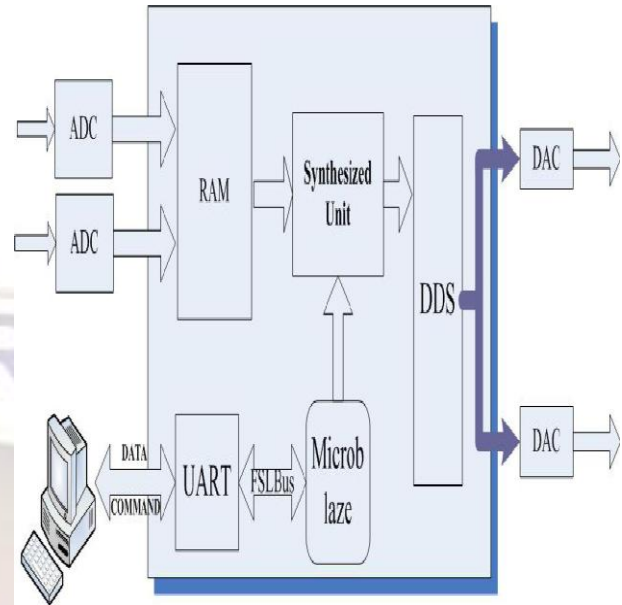


Figure 2. Processing modules of FPGA

2.2.3 Design of MicroBlaze processing

First define software systems using Microprocessor Software Specification (.MSS) readable text files which describe driver information of all peripherals. Once the system software is defined, use the Library Generator to build system-specific library C functions that map basic C functions to peripherals and to configure the C libraries. Then write the corresponding receiving program code to achieve MicroBlaze control function using the function libraries in SDK integrated environment. In the end, package the hardware structure and application software of UART controller based on MicroBlaze into ISE as a sub-module and complete software design of MicroBlaze controller. The software process flow is shown in figure 3.

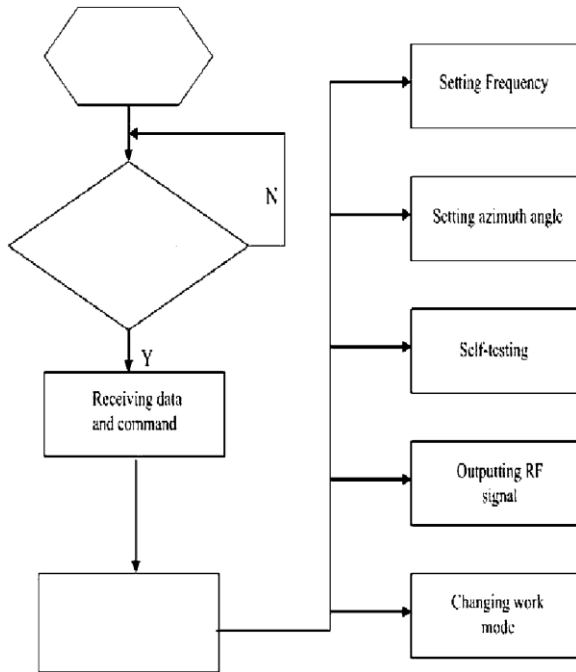


Figure 3. Software flow of MicroBlaze

IV. NUMERICAL TEST AND SIMULATION

Due to the diversity of technique requirement of navigation signal, the main task of generator is to generate different kinds of rf modulated signal. Take Automatic Direction Finder (ADF) signal for example

$$V = E\{m + M \cos(\Omega t + \theta) + V_a\} \cos \omega_c t$$

E is the signal amplitude, m is a constant, M is modulation index, Q is frequency of low frequency modulated signal, e is the azimuth angle, Va is the audio modulated signal and We is the carrier frequency.

Assume

$$E=1, m=1, M=0.3, \Omega=2\pi \times 90, \theta=0, \omega_c=2\pi \times 190k$$

the frequency of audio signal is 1020Hz and the sample frequency is 40MHz and simulate the ADF signal in MATLAB software, the result is shown in Fig. 4.

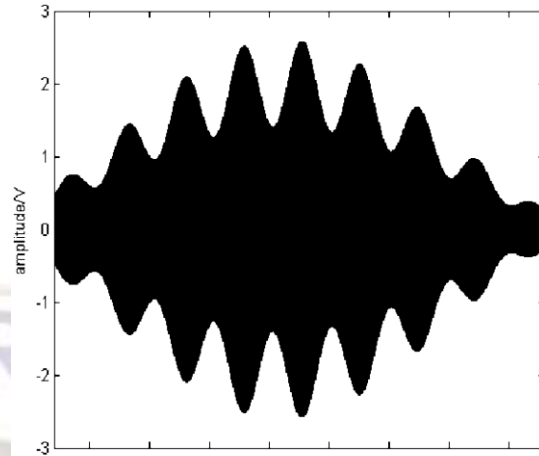


Figure.4 Simulated waveform of ADF signal
 Take another signal for example, the signal of Very-highfrequency Omnidirectional Range (VOR) can be expressed as

$$V = U_{Rm} [1 + m_A \cos(\Omega t - \theta) + m \cos(\Omega_c t + m_f \cos \Omega t)] \cos \omega t$$

U_{Rm} is the amplitude of reference phase signal, e is the azimuth angle, Q is the angular frequency at 30Hz, Q_s is the angular frequency at 9960Hz, m A is the modified factor of variable phase signals, m f is the modulation index, m is modulation of reference phase signal and W is the angular frequency of carrier signal. Due to that the frequency of VOR signal is too high and the hardware is limited in performance, we assume $U_{Rm} = 1$,

$$m_A = 1, m = 0.3, m_f = 1, \theta = 60, \omega_c = 2\pi \times 20M$$

the sample frequency is 40MHz, VOR signal is simulated in MATLAB software and the result is shown in Fig. 5.

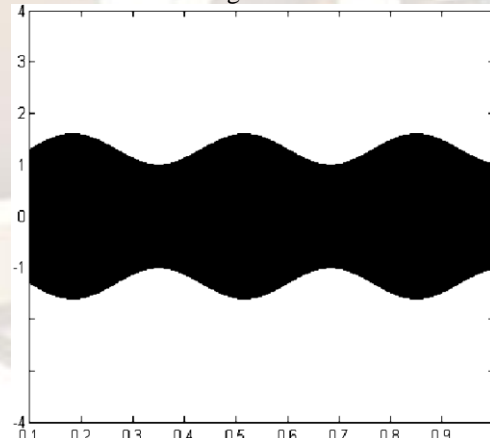


Figure. 5 Simulated waveform of VOR signal

Use the PC software to control the system to generate the ADF signal in the same condition with the MATLAB simulation and connect the generated ADF signal to the oscillator. The real ADF signal waveform is shown in Fig.6

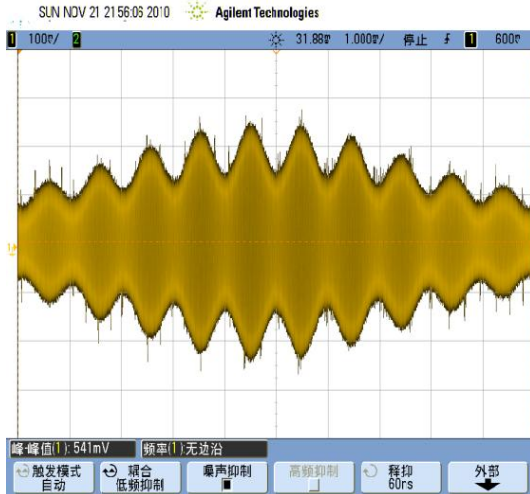


Figure.6 Real waveform of ADF signal

which is almost the same with the simulated signal in Fig. 4. Then connect the real ADF signal to the spectrum analyzer, the minimum resolution of the signal is up to 0.01Hz. Similarly, generate the VOR signal in the same condition of simulation in MATLAB and connect it to the oscillator. The real VOR signal waveform is shown in Fig.7 which is almost the same with the simulated signal in Fig. 5. Then connect the real VOR signal to the frequency analyzer, the minimum resolution of the real signal is up to 0.01Hz.

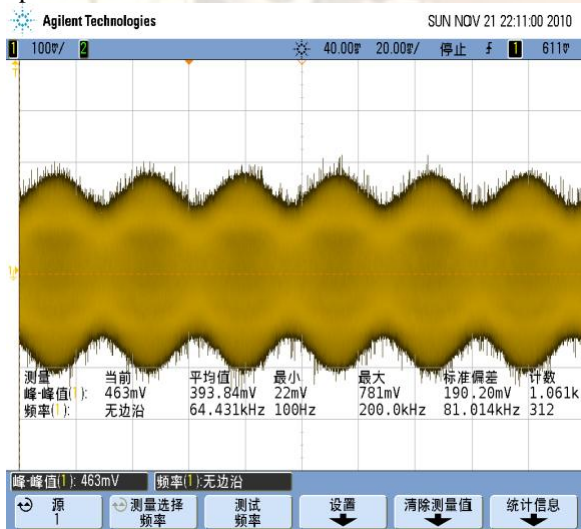


Figure.7 Real waveform of VOR signal

V. CONCLUSION

In this paper, the digital signal generator of radio navigation is implemented by soft processor Micro Blaze whose key portion is achieved in a single FPGA chip, which overcomes the disadvantage of

low accuracy and flat tuning in traditional methods. Simultaneously, various kinds of signals can be loaded in this system, obtaining more flexibility and better expandability. Through the numerical test and simulation results, the veracity and precision is confirmed. Favourable result has been acquired in practical application.

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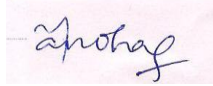
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