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# Based on DSP Builder of 2PSK Digital Modem Design

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**Abstract**

Through analysis on principles of Binary Phase Shift Keying(2PSK) modulation and demodulation, the design scheme based on DSP Builder of DDS (Direct Digital frquency Synthesizer) is put forward. By using DSP Builder complete modulation and demodulation model, carrier signal was generated by DDS signal source. The circuit hardware structure of this design is simple and easy to implement. The modularized design is rapid and efficient. Its relevent parameters can be adjusted flexibly. The desired effect can be achieved by simulation.

**Index Terms:** DDS; Carrier; digital modulation and demodulation; DSP Builder



## 1. INTRODUCTION

To facilitate the information Transmissing in communication systems, the original signal usually has to be transformed into suitable signal for transmission. This process is called signal modulation. In digital communication systems, generally the original signals (such as images, sounds, etc.) is transformed into digital signal by quantification coding, which is called base band signal, and then transmitted in the communication network through digital modulation. The patterns of modulation are different, and so are the performances of communication systems. Binary frequency shift keying which uses digital signal to modulate carrier frequency is an early used modulation mode in the transmission of information. Its main advantage is much easier to accomplish and has superior qualities of Anti-noise and Anti-decay, so it has been widely used in low-speed data transmission. [1-2]

## 2. The Principle of Digital Modulation and Demodulation

### *A. The modulation principle of 2PSK signal*

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Binary keying is a modulation method. Which uses binary digital baseband signal to control carrier signal phase, and makes the carrier signal phase jump. 2PSK is also named Binary absolute Phase Shift Keying. It is to describe digital baseband signal by using different phase of the carrier of the demodulated signal. In 2PSK, when the digital baseband signal is "1", the modulated signal has the same phase with the unmodulated signal. When the digital baseband signal is "0", the modulated signal has the reversed phase with the carrier signal. Carrier phase changes according to the modulated signal 1 or 0. Usually 0 and π are to express "1" or "0" in the binary digital baseband signal. The expression of modulated 2PSK signal in time-domain is:

$$e_{2PSK}(t) = A\cos(\omega_c t + \varphi_n) \tag{1}$$

In the above expression, $\varphi_n$ is represented the phase of the nth symbol. When it is transmitted as "0", it is assigned "0"; when it is transmitted as "1", it is assigned "1". Therefore, the formula (1) can be expressed as:

$$e_{2PSK}(t) = \begin{cases} A\cos\omega_C t & when\ probability\ is\ \mathrm{P} \\ -A\cos\omega_C t & when\ probability\ is\ (1-\mathrm{P}) \end{cases} \tag{2}$$

This kind of modulation's schematic diagram which express the different phase of the corresponding binary digital signal of carrier can be described as Fig. 1:

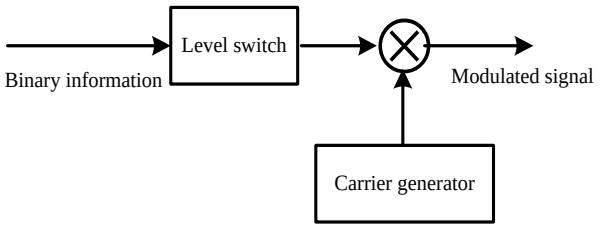


Figure 1. The principle of 2PSK direct phase-modulation

*B. The Demodulation Principle of 2PSK Signal*

The demodulation methord of 2PSK is usually used by coherent modulation mode. The principle of the demodulator can be described as Fig. 2. The essence of the demodulation processing is to compare the polarity of input modulated signal.

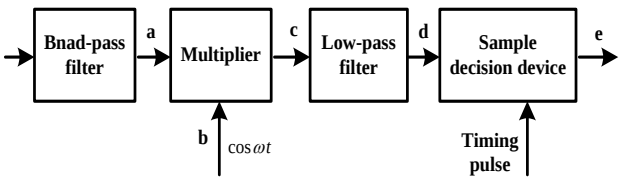


Figure 2. The principle diagram of 2PSK coherent demodulation

The process of demodulation is that the demodulated signal $e_{2PSK}$ and noise n(t) pass through the band-pass filter first, then, multiply with the local carrier produced from the receiver. The local carrier should have the same phase and frequency with sented carrier. After that digital baseband signal is obtained from each signal of multiplier by using low-pass filter. As the effect of noise and the unideal transmission characteristics, the output waveform by low-pass filter will be distorted. The original digital baseband pulse signal will be produced after sampling, judging and reshaping.

### *C. The Principle of DDS*

The technology of DDS (Direct Digital Synthesizer) is a synthesis technology that converts Digital signals through DAC into analog signals. The fundamental principle is to use total digital technologies, forming the synthesis waveform from the phase conception directly. DDS has a high resolving capability, and it can achieve frequency switching in a high speed. It can also keep the sequence of phase along with the changes of frequency. DDS can fullfil the digital control of phase modulation and amplitude modulation easily. It is widely used in electronic systems and digital modulation and demodulation.[3-4]

DDS mainly consists of phase accumulators, phase modulator, sine ROM lookup tables, D/A converter and other components as Fig. 3shows. In the Fig. 3, the first 3 part is digital part of the DDS structure, and they have the function of digital control frequency synthesized. Phase accumulators is the core of DDS which can complete phase accumulate computation. While working, it consists of DDS under the control of refence CLK, and the frequency control words are added up to by accumulators to get the corresponding phase data. Phase modulator receiving the phase output from the corresponding accumulators phase output, is mainly used for signal phase modulation, with the output data as sampling address, for addressed sine ROM look-up table to complete phase - amplitude transformation, and output different amplitude coding. Corresponding ladder waves are obtained after D/A converter. Finally the low-pass filter to the ladder waves are smoothly dealt with, and continuous variation of the output sine wave can be gotten by frequency control word decision.

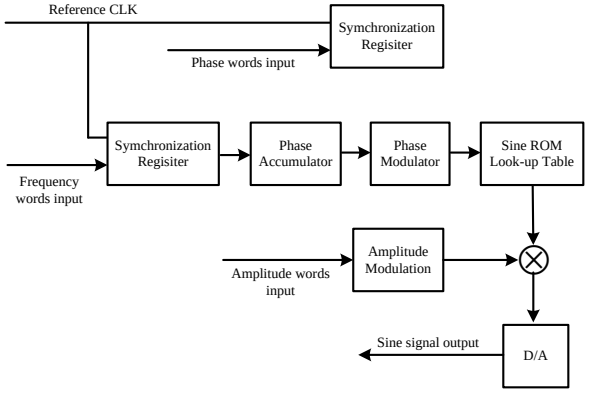


Figure 3. The Principle of DDS

## 3. The Design of Modem System Based on DSP Builder

DSP Builder is a system-upgrade tool which is issued by the company ALTERA for developing DSP. As a Simulink toolbox of MATLAB, it makes sure that the DSP system designed by FPGA completely through the graphical interface of Simulink to build model and simulate system-level. The designed model can describe the language transformation to the VHDL hardware and can automatically invoke the QUARTUS II software to complete the download of comprehensive, nets table generation and the configuration and FPGA device adapter , making a systematic description and hardware combined together. It fully displays the development characteristics and advantages of the modern electronic design automation. [5-7]

### *A. The Design of Carrier Signal Generator*

The DDS signal generator established according to Fig. 3 is showed in Fig. 4. All the basic components designed by DSP Builder are included already. For each component, we only need to connect all of them one by one after each parameter is set. The digit of phase accumulators of is 32 bit, in order to reduce the capacity of ROM, it will be truncated for 10 bit. The chief module parameters is following:

ZHXCHZHB module,
Set parameters "Bus Type" as "Signed Integer",
Set parameters “Output Data [number of bits]”as“10”,
Set parameters “Address Width” as “10”,
Set parameters “MATLAB Array” as “511*sin ( [0: 2*(pi/2^10):2*pi] )”,
Set parameters “Use LPM” as “off”,
Set parameters “Register Address” as “off”.
xwkjp module,
Set parameters “Number of Inputs” as “2”,
Set parameters “Add (+) Sub (-)” as “++”,
Set parameters “Pipeline” as “on”,
Set parameters “Use Control Inputs” as “off”,
Set parameters “Clock Phase Selection” as “1”.
Fdkzhq module,
Set parameters “Pipeline” as “2”,
Set parameters “Use LPM” as “off”.

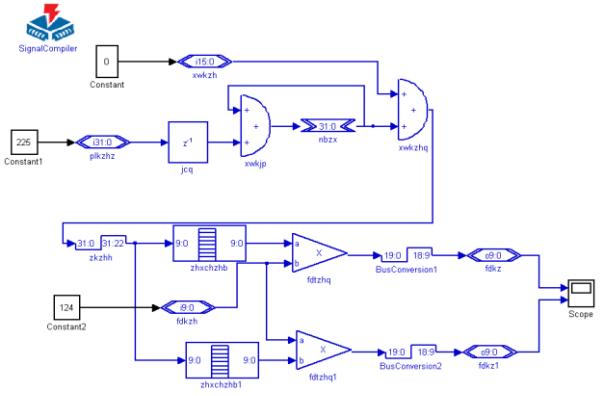


Figure 4. DDS model in DSP Builder

In order to modulate and demodulate the corresponding sine wave simultaneously, two sine ROM look-up tables are needed to generate coherent sine wave. After turning on the oscilloscope, the waveform can be seen as Fig. 5 shows.

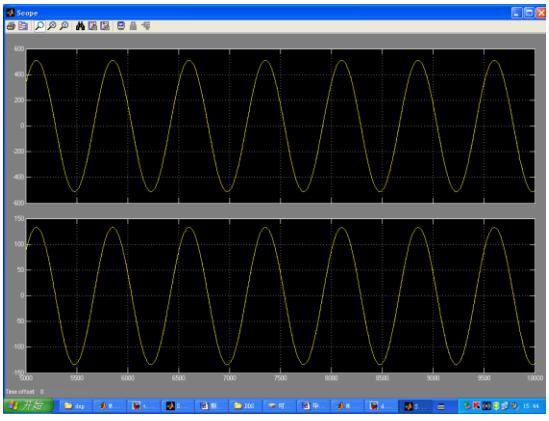


Figure 5. Output Waveform of DDS

### *B. The Design of Modem System*

According to the principle of modulation and demodulation, we can build modem system model (as Fogure 6 below) by calling for demanded module of DSP Builder with MATLAB/ Simulink. In the Fifure 6,the sine signal is generated by DDS, the pulse wave is binary sequency for simulating input. FIR filter is a low-pass filter, and it is adopted to the IP core design of ALTERA company. It has been optimized in the speed, the performance and so on. In order to reduce digital system data quantity, sampling frequency is set for 4 times of the sine wave signal frequency. The concrete parameters Settings and the amplitude frequency characteristics are shown in Fig. 7.

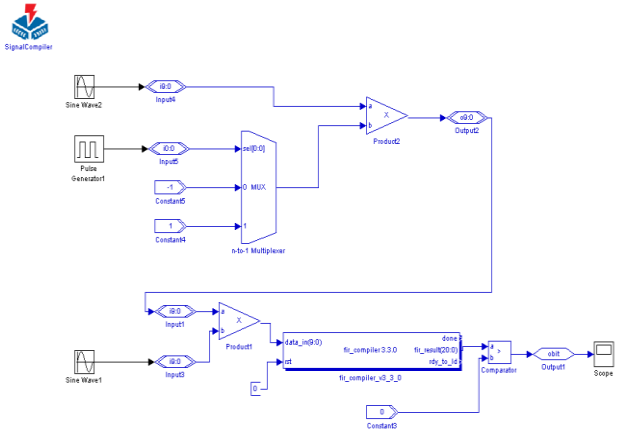


Figure 6. The Modem System Model Based on DSP Builder

From the above modem system model and carrier signal unit model, it will happen unified in together, and constitute a system overall algorithm model. The simulation results will be gotten as shown in Fig. 8 shows. The first part is binary signals, and the second part is modulated signals, and the third part is the multiplier output, and the fourth part is binary signal which is processed by entry comparator. The fifth part is sine signals, the last part is filter output.

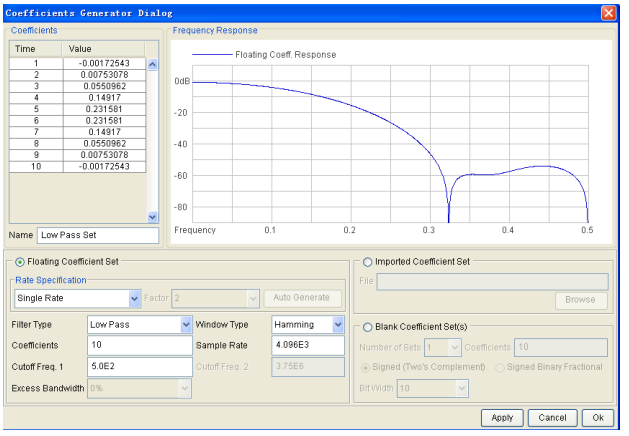


Figure 7. FIR Compiler modules specific parameter and amplitude frequency characteristics

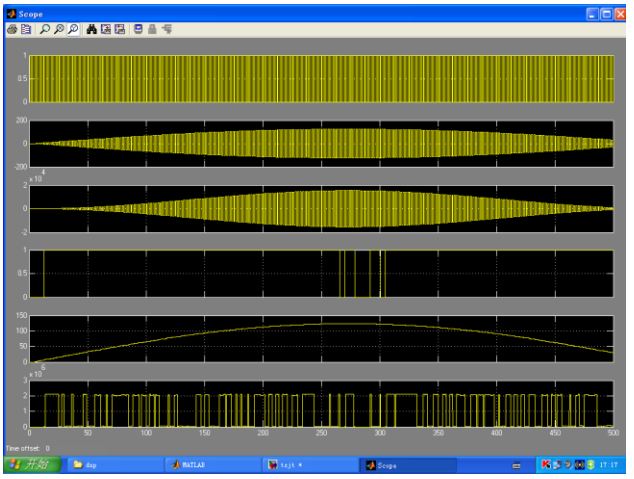

Figure 8. Modulation and Demodulation Results

## 4. Conclusions

The scheme based on DSP Builder is explicit and direct, much cumbersome process design work can be avoided, and the problem of system-wide can be designed and modified in Simulink directly so that a lot of time can be saved. In addition, scalability of the system is good. What's more, based on DDS technology, this system can also integrate more patterns of modulator.

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