STUDIES OF SYNTHESIZED AND IMPLEMENTED DIGITAL FREQUENCY MODULATOR-DEMODULATOR

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Abstract: This paper presents a synthesized circuit of digital frequency modulator-demodulator. Among the possible variants for implementing a digital frequency demodulator: on the basis of a non-coherent scheme, in which direct frequency demodulation of the oscillations is performed; differential-coherent, in which the digital series is differentially encoded before the frequency manipulation; coherent, where synchronous demodulation is performed using an automatic frequency adjustment system as in this case a specialized PLL integrated circuits is used and realized with a Digital Signal Processor, the first one has been chosen. The non-coherent demodulator contains a two-unit band-pass active filter, an amplitude detector and inverter. The obtained simulation and experimental results of the digital frequency modulator-demodulator studies are also presented and analyzed.

Keywords: digital, frequency, modulator-demodulator, studies.

ITHEA Keywords: C.2 Computer-Communication Networks; C.3 Special-Purpose and Application-Based Systems: Signal Processing Systems

Introduction

The transmission of information at long distances is related to the use of modulation and demodulation processes and corresponding devices - modulators and demodulators. The improvement of communications systems in recent years has led to their digitalization - of the input information signals, their method of processing and their transmission over the communication channel.

The block diagram of a communication system is shown in Fig. 1. The Transmitter, Receiver and Transmission environment form the so-called Radio channel or Connection channel.

![Figure 1. The block diagram of a communication system](image-url)
Presentation

The block diagram of a digital frequency modulator-demodulator is shown in Fig. 2. The input digital signal in the frequency shift keying (FSK) modulator, the information carrier, is converted into a continuous one, which is transmitted over an analogue connection channel. The input continuous signal in the FSK demodulator is converted into an output digital signal carrier of the information.

![Block diagram of digital frequency modulator-demodulator](image)

Figure 2. Block diagram of digital frequency modulator-demodulator

The FSK modulator will be built with a Schmitt-trigger comparator using different capacities to provide a different frequency of output signal and FSK demodulator - of a non-coherent scheme on the basis of the block diagram in Fig. 3.

![Block diagram of a non-coherent digital frequency demodulator](image)

Figure 3. Block diagram of a non-coherent digital frequency demodulator
The non-coherent FSK demodulator consists of a frequency-to-amplitude converter and an amplitude detector. The two frequencies $f_{C1}$ and $f_{C2}$ are in the falling of the amplitude-frequency response (AFR) of low-pass filter or the rising or falling slope of the AFR of band-pass filter for which the voltage transmission coefficient is different.

The circuit of the synthesized digital frequency modulator-demodulator is shown in Fig. 4. The non-coherent demodulator containing the two-unit band-pass active filter - Operational Amplifiers U2 and U3, amplitude detector (U4) and inverter (U5) because the output signal is degraded in relation to the input. The circuit of Fig. 4 has been entered in the working environment of the MultiSIM software and simulation studies have been performed and complete technical documentation has been developed using UltiBOARD module of Circuit Design Suite package. A laboratory model of the synthesized digital frequency modulator-demodulator (Fig. 4) has been implemented which has also been studied experimentally.

Figure 4. Circuit of the synthesized FSK modulator-demodulator
1. Simulation results from the study of the synthesized FSK modulator-demodulator

In Fig. 5 is shown the oscillogram of the modulation and frequency modulated signal of the digital frequency modulator with Schmidt's trigger. The measured output frequency at logic 1 of the input TTL signal is $f_1 = 3.68$ kHz and at logic 0 it is $f_0 = 6.72$ kHz. Fig. 6 presents the oscillogram of the input (in red color) and output (in blue color) signals of the synthesized FSK modulator-demodulator.

![Oscilloscope-XSC1](image)

Figure 5. Oscillogram of the modulation and frequency modulated signal of the digital frequency modulator with Schmidt's trigger - node 2
2. Experimental results from the study of the FSK modulator-demodulator implemented in practice

The experimentally obtained oscillograms in the specified nodes of the synthesized and implemented circuit of a digital frequency modulator-demodulator (Fig. 4) are shown in Figures 7 ÷ 12. A generator is connected to the input of the circuit, as the applied signal is bipolar with rectangular pulses with amplitude from peak to peak $U_{PP}$ 5 V, frequency 500 Hz and 50 % duty cycle.

The oscillogram of the input modulation signal supplied by the set generator - bipolar symmetric rectangular pulses with the amplitude $U_{PP}$ of 5 V and a frequency of 500 Hz is shown in Fig. 7. The type...
of signal that is fed to the input of the FSK modulator (node 2 of the OA U1) with amplitude $\Delta Y = 1,86 \text{ V}$ and frequencies $f_1 = 3,79 \text{ kHz}$, $f_0 = 6,58 \text{ kHz}$ respectively for logic 1 and logic 0 is presented in Fig. 8. Its shape is triangular with a pronounced increasing forward front, with minimal parasitic amplitude modulation when frequency varies.

Figure 7. Oscillogram at the input digital modulation signal - node 1
Figure 8. Oscillogram at the input of FSK modulator at logical 0 with $f_0 = 6.58\ kHz$ - node 2 of OA U1

The obtained oscillogram at the output of the FSK modulator (node 6 of the OA U1) is presented in Fig. 9 as rectangular pulses with the same amplitude and the same frequencies $f_1 = 3.79\ kHz$, $f_0 = 6.58\ kHz$ respectively for logic 1 and logic 0.

The types of signals for the two operating frequencies $f_1 = 3.79\ kHz$ and $f_0 = 6.58\ kHz$ after the filtration of the first BAF (BAF1) - node 6 of the OA U2 are shown on the oscillogram in Fig. 10.

The oscillogram of the output of BAF2 (node 6 of OA U3) for the two operating frequencies is shown in Fig. 11. It shows a minimum change in pulse width and a slight decrease in the frequency of the lower operating frequency. At the higher operating frequency ($f_0 = 6.58\ kHz$), a symmetrical and mirror change in amplitude of the pulses within the respective half-period is observed.
The signal type, after the Grid rectifier circuit and at the input of OA U4 (node 2), is shown on the oscillogram in Fig. 12. It is characterized by minimal amplitude variation, has the frequency of the input modulation signal $f = 500$ Hz and a well-pronounced rear front. After passing through the amplitude detector (OA U4) and the inverter (OA U5), the type of oscillogram of the output signal as regards the input modulating one, is analogous to that shown in the simulation studies - Fig. 6.

Figure 9. Oscillogram at the output of the FSK modulator with $f = 6.58$ kHz - node 6 of OA U1
Figure 10. Oscillogram at the output of the BAF1 ($f_0=6.58$ kHz) - node 6 of OA U2

Figure 11. Oscillogram at the output of the BAF2 - node 6 of OA U3 ($f_0=6.58$ kHz)
Conclusion

The behavior of the synthesized circuit of a digital frequency modulator-demodulator during simulation and experimental studies is analogous as the form and character of the intermediate signals in the individual nodes are preserved.

The presented simulation and experimental results obtained illustrate the work and explain the principle of operation of the synthesized circuit of a digital frequency modulator-demodulator.

Bibliography


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