

SIMULATION OF MODULATORS AND DEMODULATORS IN THE “NI MULTISIM” PROGRAM

Ya.T. Yusupov, N.T. Baymatova,
Tashkent State Technical University, Tashkent, Republic of Uzbekistan
e-mail: yarashbekyusupov@mail.ru

Abstract. The article discusses the possibilities of analyzing the operation of modulators and demodulators using the NI MULTISIM modeling program. Models of the modulator and demodulator and recommendations for analyzing their characteristics are given.

Keywords: NI MULTISIM, signal, modeling, amplitude modulator, demodulator.

An analysis of the component libraries of the NI MULTISIM program demonstrates that it is fully capable of modeling fragments of high-frequency devices, allowing the study of their operational features across a wide range of frequency circuits built on various principles [1, 2].

The program's ability to analyze the characteristics of active circuits in the high-frequency range is largely determined by the availability of components in its libraries. While transistors and diodes suitable for high-frequency applications are widely represented in the libraries, the number of integrated circuits (ICs) available for this frequency range is significantly smaller. As a result, realistic modeling can generally be performed up to a frequency of 300 MHz. However, the use of virtual components enables testing circuit functionality conceptually across a broader frequency range. For instance, the virtual analog multiplier model (Multiplier) from the Sources/Control_Function_Blocs library can be used to create an amplitude modulator, synchronous demodulator, frequency converter, analog high-frequency switch, and more [3].

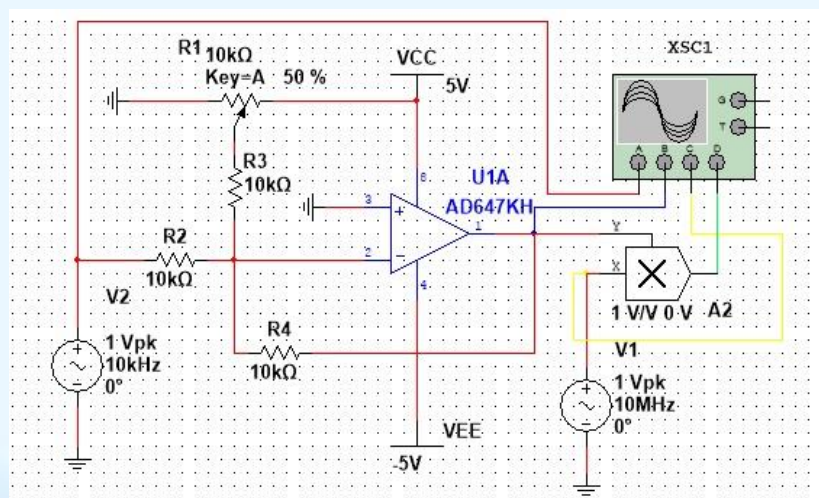


Fig.1. Model of an amplitude modulator constructed using a virtual multiplier

An example of an amplitude modulator model based on a virtual multiplier is shown in Figure 1. The operational amplifier (AD647KH) is configured as an inverting summator, producing a modulating voltage at its output. This modulating voltage is the sum of an alternating voltage with a frequency of 10 kHz and a negative constant voltage, which can be adjusted using potentiometer R1 within the range of 0 to 5 V.

The output voltage of the amplifier is applied to the X input of the multiplier, while the Y input receives the carrier signal voltage with a frequency of 10 MHz. When there is no constant component in the output signal of the amplifier U1A, the multiplier output produces a balanced amplitude modulation signal (in the absence of a modulating signal, the carrier frequency signal is suppressed at the multiplier output). If a constant component is present, a standard AM signal is generated (Figure 2). By adjusting the magnitude of the constant component of the modulating oscillation and the amplitude of its variable component, the modulation depth can be varied over a wide range [4, 5].

Using the amplitude modulator model, the principles of construction and operation of synchronous demodulators, which are widely used not only in radio engineering devices, can also be examined.

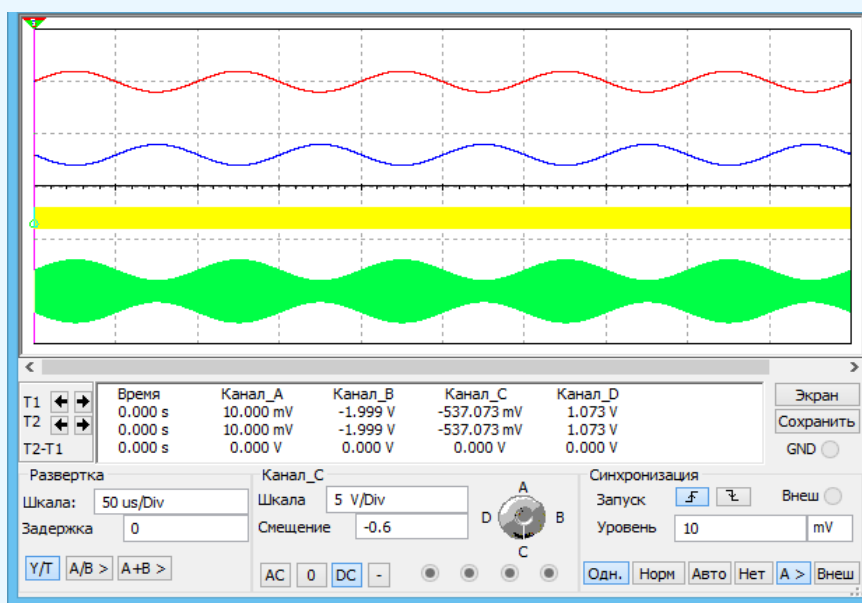


Fig.2. Signals at the inputs and output of the studied amplitude modulator

To construct a synchronous demodulator, it is sufficient to add another multiplier and a signal generator with a frequency equal to the carrier frequency of the AM signal to the circuit shown in Figure 1. It is important to note that the initial phases of the signals from all generators placed on the NI Multisim workspace are synchronized and equal to zero. By setting different initial phase values in one of the generators (either the carrier or the one controlling the synchronous demodulator), the dependence of the demodulator's efficiency on the phase can be studied.

Figure 3 shows a circuit containing a synchronous modulator built on multiplier A2 and a harmonic signal generator with a frequency of 10 MHz (local oscillator), as well as the previously discussed amplitude modulator.

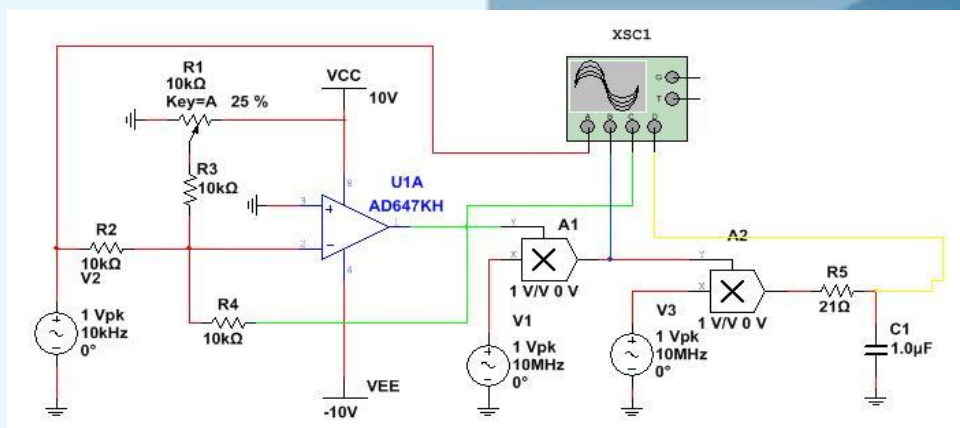


Fig.3. Models of an amplitude modulator and a synchronous demodulator constructed using a virtual multiplier

The signal at the output of the synchronous demodulator with an initial local oscillator phase of 0 degrees is shown in Figure 4. As can be seen, when the phases of the carrier signal generator and the local oscillator coincide, the signal at the input of the amplitude modulator and the output of the synchronous demodulator are in phase.

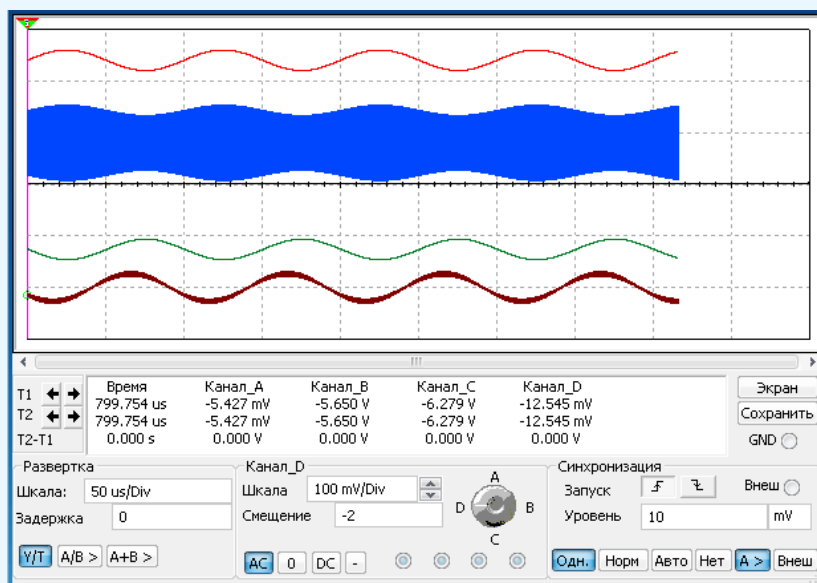


Fig.4. Signals at the input and output of the synchronous demodulator when the phases of the carrier generator and local oscillator match

The output signal of the synchronous demodulator at the initial phase of the local oscillator signal of 90 degrees is shown in Figure 5. As seen, when the phase shift between the signals of these generators is 90 degrees, the signal at the output of the synchronous demodulator is absent.

The output signal of the synchronous demodulator at the initial phase of the local oscillator signal of 180 degrees is shown in Figure 6.

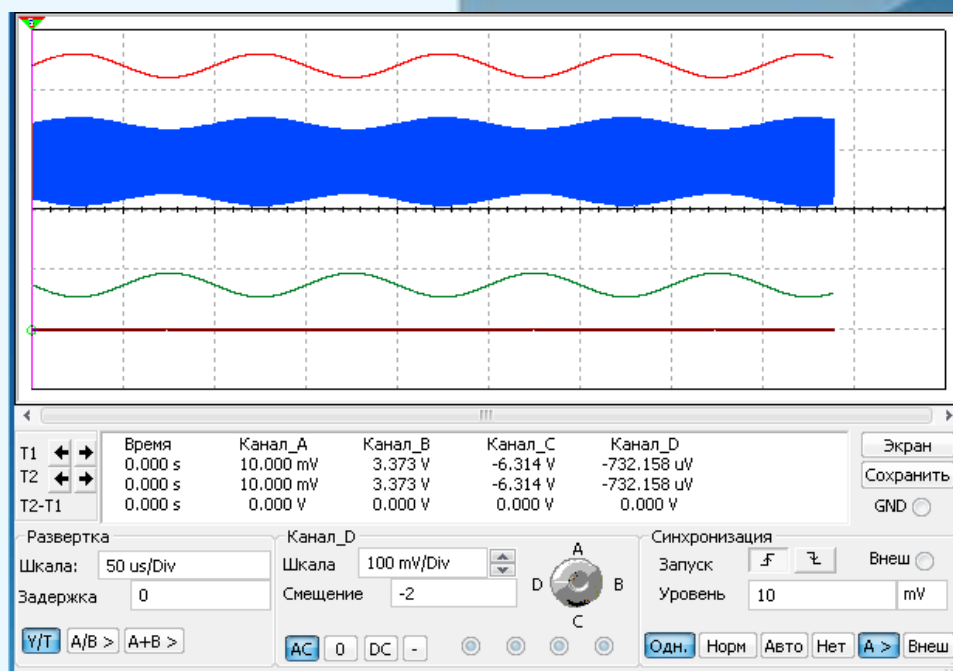


Fig.5. Signals at the input and output of the synchronous demodulator with a phase shift of 90 degrees between the signals of these generators.

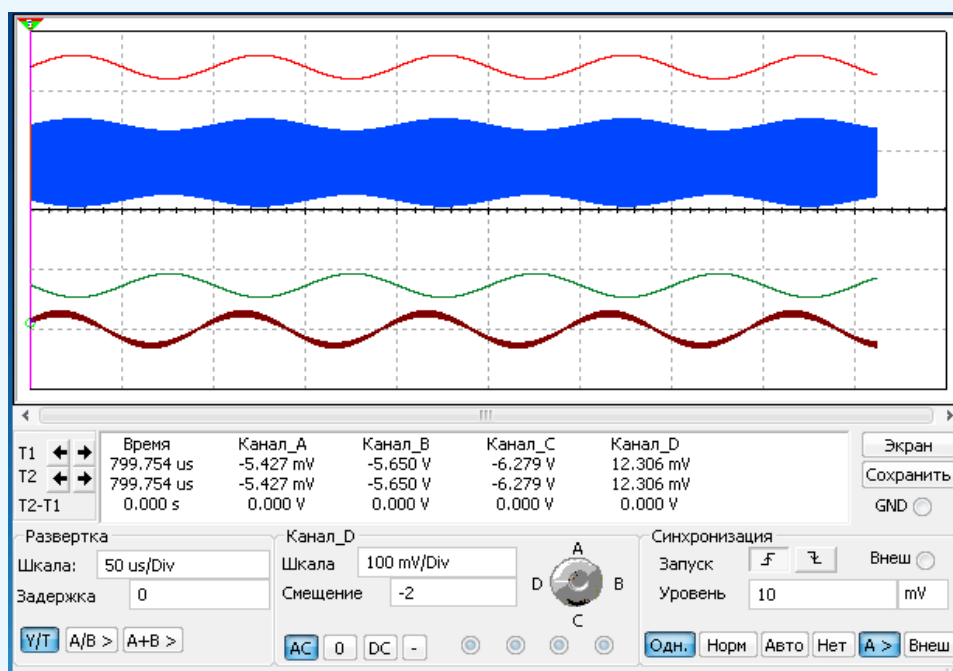


Fig.6. Signals at the input and output of the synchronous demodulator with a phase shift of 180 degrees between the signals of these generators.

As seen, when the phase shift between the signals of these generators is 180 degrees, the signal at the input of the amplitude modulator and at the output of the synchronous demodulator are opposite in phase. All obtained results are consistent with the theory. The simulation software NI MULTISIM allows for the analysis of characteristics and the study of the behavior of high-frequency devices across a wide frequency range.

Conclusions

The conducted research demonstrates the capabilities of the NI Multisim simulation software for explaining the processes occurring in both simple and more complex electronic circuits. The advantage of this approach is that, during the presentation of the material, one can quickly change the parameters of elements as well as the circuit configuration. This, in turn, allows for a clear real-time demonstration of the results on a computer screen. Furthermore, it gives the instructor the opportunity to create individual simulation tasks for each student, while students can independently conduct research on a given topic. The use of NI Multisim in the educational process enables the creation of assignments for students to develop and independently analyze the operation of various analog and digital devices.

References

1. Makarenko V.V. Using Ni Multisim To Explain The Am-Signal Demodulation Processes. Physical and Mathematical Education. 2019. Issue 1(19). P. 122-129.
2. Макаренко В.В. Моделирование радиоэлектронных устройств с помощью программы NI Multisim. Электронный журнал "Радиоежегодник". Выпуск: апрель, 2013 (23). С. 141-267. URL: <https://www.rlocman.ru/book/book.html?di=148191>
3. Шестеркин А. Н. Система моделирования и исследования радиоэлектронных устройств Multisim 10. Москва: ДМК Пресс, 2012. 361 с.
4. Антипенский Р.В., Фадин А.Г. Схемотехническое проектирование и моделирование радиоэлектронных устройств. Москва: Техносфера, 2007. 128 с.
5. Хернтер Марк Е. Multisim® 7: Современная система компьютерного моделирования и анализа схем электронных устройств. (Пер. с англ. Осипов А.И.). Москва: Издательский дом ДМК-Пресс, 2006. 488 с.