E3S Web of Conferences **417**, 03011 (2023) https://doi.org/10.1051/e3sconf/202341703011
GEOTECH-2023

Methods for reducing the temperature components of magnetomodulation DC convertors errors

Sultan F. Amirov*, Nodir* O. Ataullayev*, Amin* O. Ataullayev*, Bobur* Q. Muxammadov*, and *Ahror* U. Majidov

Navoi State University of Mining and Technologies, Navoi, Uzbekistan

Abstract. Reliability is called not only one of the main characteristics of the magnetic modulation DC converters, but also the ability to correctly perform the required function of the measuring device in the specified operating modes and operating conditions for a certain period of time. One of the main tasks in the development of magnetic modulation DC converters is to reduce the number of inference errors. Magnetic modulation DC converters errors include the main errors which are technological and corrective errors, internal sources of additional errors, external sources of additional errors which can be static errors, dynamic errors.

1 Introduction

To improve the stability of the characteristics of measuring transducers, the negative feedback method (NFBM) is widely used.

If we designate the feedback coefficient as K_{NFBM}, then the absolute error of magnetic modulation DC converters with NFBM, reduced to the input, is found by the expression: static

$$\Delta U_{out} = \frac{\Delta U}{\text{К}_{st}} \pm \frac{\Delta \text{К}}{\text{К}_{st}}(I_{\text{x}}), \tag{1}$$

here: К_{st}, $\Delta\text{К}$ - static transmission coefficient of magnetic modulation DC converters and its increment.

$$\Delta U_{out\approx} \frac{\Delta U}{K_{st}}\left(1 \pm \frac{\Delta K}{K_{st}}\right) \pm \frac{1}{K_{\text{NFBM}} K_{st}} \frac{\Delta K}{K_{st}} I_{\text{x}} \,. \tag{2}$$

The magnetic modulation DC converters error in the absence of NFBM is determined by expression (1). From comparisons (2) and (1) it can be seen that the introduction of the NFBM reduces only the multiplicative error, the additive error changes slightly under the influence of the NFBM [1]. Additive errors are noticeably reduced only in those cases when, with the introduction of the NFBM, in order to maintain the same value of the output signal, the nominal value of the input value for a given magnetic modulation DC converters is increased.

* Corresponding author: muxammadov.bobur@mail.ru

2 Materials and methods

Let us determine the required parameters of the NFBM circuit for a given error value (ΔU_{NFBM}). Assume that with the introduction of the NFBM, the error should decrease by m times [2]. Therefore, the current I_x in the input circuit should be increased by the same amount. However, there is practically no possibility of increasing the current I_x, since the converted current is a controlled value (with the exception of the case where part of the controlled current is supplied to the magnetic modulation DC converters by dividing the current into two components flowing through the main bundle and the tap). The value of the input action can be increased by increasing the magnetizing force of the controlled circuit by increasing the number of turns of the input winding W_{in} [3].

The transmission coefficient of the magnetic modulation DC converters NFBM is equal to:

$$K = \frac{K_{\text{st}}}{1+K_{\text{st}}K_{\text{NFBM}}} . \quad (3)$$

Output voltages of magnetic modulation DC converters without and with NFBM:

$$\begin{cases} U_{out} = K_{\text{st}}W_{in1}I_{\text{x}}, \\ U_{out(\text{NFBM})} = KW_{in2}I_{\text{x}}, \end{cases} \quad (4)$$

Where W_{in1}, W_{in2}- the number of turns in the input winding of the magnetic modulation DC converters, respectively, without NFBM and with NFBM [4].

Equating U_{out} and U_{out} (NFBM) with each other, taking into account (3), we find:

$$K_{\text{NFBM}} = \frac{W_{in2}-W_{in1}}{K_{\text{st}}W_{in1}} = \frac{(W_{in2}-W_{in1})I_{\text{x}}}{K_{\text{st}}W_{in1}I_{\text{x}}} = \frac{(W_{in2}-W_{in1})I_{\text{x}}}{U_{out}} . \quad (5)$$

For the considered magnetic modulation DC converters we have: $K_{\text{NFBM}} = \frac{W_{\text{NFBM}}}{R_{\text{NFBM}}}$.

The magnetic modulation DC converters feedback coefficient K_{fb} is limited by a finite number of turns in the winding W_{fb}.. For example, for the considered magnetic modulation DC converters with an open circuit of the NFBM, the maximum error was about 2% of the maximum signal [5]. With a closed NFBM circuit with a constant static transmission coefficient K_{st} and a correspondingly increased number of W_{in}, this error was already about 0.74%.

To increase the reliability and reduce the error of the magnetic modulation DC converters, the most acceptable method is the majority redundancy with the help of a majority part (MP), at the output of which the transmitted signal appears only if it is applied to most of the inputs of the MP [6].

Since MP for redundancy of devices with analog output signals is a rather complex device, it is advisable to use pulse-width modulation of the output signal of the magnetic modulation DC converters. In this case, the signal takes on the value 0 or 1, and the MP circuit is relatively simple [7].

The best is the MP circuit with an odd number of inputs, which works according to the principle of 2 out of 3 and implements the function m + 1 out of 2m + 1. The MP scheme for redundant magnetic modulation DC converters according to the 2 out of 3 principle is shown in Figure 1. The functional diagram of the redundant magnetic modulation DC converters is shown in Figure 2. magnetic modulation DC converters consists of three identical conversion channels. Each channel consists of a magnetic transistor multivibrator (MTM), an amplifier A1 and a null organ A2 that converts a continuous signal into a pulse-width signal [8]. A sawtooth voltage is supplied to the inputs of null-organs from a sawtooth voltage generator (SVG).

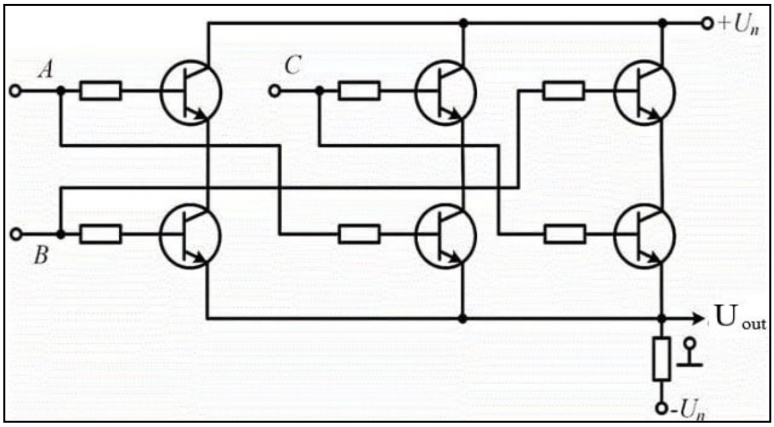

Fig. 1. Majority body for 2 out of 3 reservations.

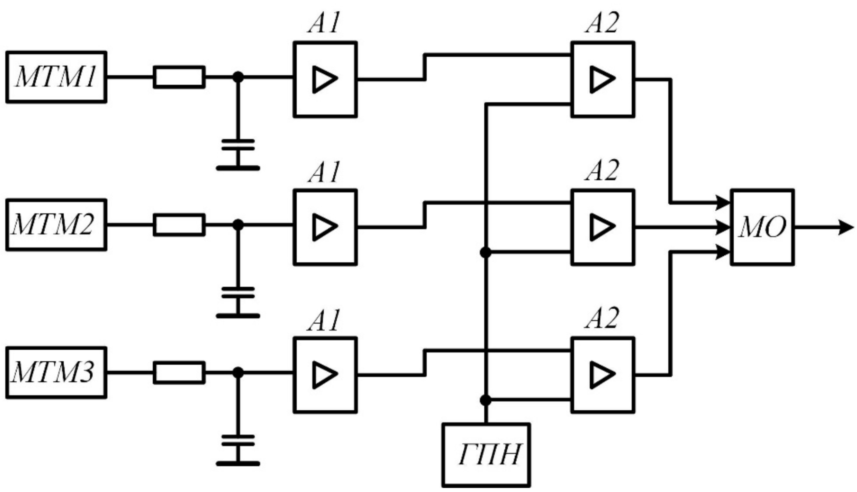

Fig. 2. Functional diagram of a redundant magnetic modulation DC converters.

Due to the fact that MP is an averaging element that transmits the average value of the input signal to the output, then with the majority redundancy, an increase in the reliability and accuracy of the output signal from its average value [9].

3 Results and discussion

If we assume that the random variables x_i are not correlated with each other and have the same normal distributions, then the MP output signal is also normally distributed and for any odd input signal is characterized by the value:

$$\sigma_m = \frac{2^{m-1}\left(\frac{m-1}{2}\right)!\left(\frac{m-1}{2}\right)!}{m!}\sigma. \quad (6)$$

For our case when m=3:

$$\sigma_m = \frac{2}{3}\sigma,$$

those. magnetic modulation DC converters majority reservation according to the 2 of 3 method allows to reduce by 1/3 the standard deviation of the output signal from its average value.

Thus, in order to reduce the error and improve the reliability of the developed magnetic modulation DC converters, the most acceptable method is the majority reservation using a majority body with an odd number of inputs. In this case, the reduction of the conversion error is achieved by reducing the standard deviation of the output signal from its average value [9]. It is shown that if for the known magnetic modulation DC converters with an open NFBM circuit the maximum error was about 2% of the maximum signal, then with a closed NFBM circuit, a constant static transmission coefficient and an increased MMF of the input circuit of the converter due to the manufacture of the magnetic system in the form of several coaxially arranged toroidal cores interconnected by diametral jumpers, this error was already about 0.74%. The condition for the minimum temperature drift of the output voltage developed by the magnetic modulation DC converters has been obtained and it makes it possible to reduce the temperature error of the magnetic modulation DC converters by approximately 1.8 times without additional complication of the circuit.

4 Conclusion

An analysis of the error sources developed by magnetic modulation DC converters showed that the greatest influence on the parameters of their elements, and therefore on the conversion accuracy, is a change in the ambient temperature. It was found that the error that occurs when the parameters of a ferromagnetic core change under the influence of temperature is approximately two orders of magnitude lower than the errors that occur when the parameters of other elements of the magnetic modulation DC converters change with temperature. It is shown that the greatest contribution to the error value is made by the change in the gain coefficients of magnetic modulation DC converters transistors under the influence of temperature, and the smaller their value and the more they differ from each other, the greater the temperature drift of the magnetic modulation DC converters output voltage. It has been established that in order to exclude the effect of changing the gains of the converter transistors on the error, it is necessary to select transistors with the highest possible gain. For example, when using transistors with a gain of 100, the magnetic modulation DC converters error is reduced by more than three times. It has been established that in order to reduce the error and improve the reliability of the developed magnetic modulation DC converters, the most acceptable method is the majority reservation using a majority body with an odd number of inputs. In this case, the reduction of the conversion error is achieved by reducing the standard deviation of the output signal from its average value.

References

1. N.O. Ataullayev, D.F. Nizomova, B.Q. Muxammadov, Journal of Physics: Conference Series **2094(5)**, 052039 (2021)
2. N. Ataullayev, A. Ataullayev, S.M. Karimtoshovich, IOP Conference Series: Materials Science and Engineering **1047** 012030 (2021)
3. A.I. Qarshibaev, B.Sh. Narzullaev, H.Sh. Murodov, J. Phys.: Conf. Ser. **1679** 022074 (2020)
4. I.U. Rakhmonov, A.N. Tovbaev, L.A. Nematov, T.Sh. Alibekova, Journal of Physics: Conference Series **1515** 022050 (2020)
5. S.F. Amirov, A.O. Ataullaev, International Journal of Advanced Research in Science, Engineering and Tehnology **7(11)** 2-4 (2020)
6. A.B. Novgorodtsev, *Calculation of electrical circuits in MATLAB: A training course* (St. Petersburg, Peter, 2004)

7. I.N. Bronstein, K.A. Semendyaev, *Handbook of Mathematics for Engineers and students of Higher Education* (Moscow, Nauka. Gl. ed. Phys. -mat. lit., 1986)
8. O.A. Jumaev, D.S. Karpovic, M.T. Ismoilov, AIP Conference Proceedings **2656**, 020026 (2022)
9. O.A. Jumaev, R.R. Sayfulin, M.T. Ismoilov, G.B. Mahmudov, Journal of Physics: Conference Series **1679(5)**, 052018 (2020)