

*O.S. Melnyk, A.M. Mikolushko, T.K. Denysko
(National Aviation University, Ukraine)*

Reprogrammable multiplexer nanocircuits

In work realized automated methods of multiplexer nanocircuit reprogramming for reproducing logical functions of several arguments. On modern automated systems the design and verification of nanodevices is realized.

Reprogramming of multiplexers as logical elements.

Multiplexers can be used as simple FPGAs. The essence of the use of the multiplexer as a universal logical zero lies in the fact that its address inputs are used as information, and the arguments of the reproducible function are fed to them, and the information inputs play the role of the reprogrammed.

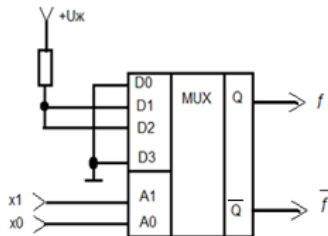


Fig. 1. Typical circuit of the LED

On the multiplexer ($4 \rightarrow 1$), it is possible to reprogram the 16 most simple functions of two arguments. For this purpose the binary arguments x_1 and x_0 should be applied on the address inputs A1 and A0 and the information $D_2 \dots D_0$ - should be reprogrammed with the logical constants of these arguments.

If you need to implement the logical function of a large number of input variables, you can use the structure of the multiplex tree. However, with a small number of arguments, this problem can be solved by another method, namely by choosing the of configuration signals not from the $\{1,0\}$ set, as it was done above, but from the set $\{1,0, x_i\}$, where x_i is one of the arguments of displayed function. In this case, it is possible to implement a logical function on the multiplexing nanoscale without additional hardware costs, the number of arguments of which is one unit greater than the number of its address inputs.

For example, on a multiplexer ($4 \rightarrow 1$) we implement the logical function of three input variables of the following form:

$$f = x_2 \vee x_1 \bar{x}_0 \vee \bar{x}_1 x_0 \quad (4)$$

In order to obtain a disjunctive normal form (DNF) of logic functions it's used the bracket transformations, that is, incomplete products (terms) are multiplied by single sum of missing arguments and functions: $(x_i \vee \bar{x}_i)$, $(x_i \vee 1)$, $(f_i \vee \bar{f}_i)$, $(f_i \vee 1)$ or add null products $(x_i \bar{x}_i)$, $(x_i 0)$, $(f_i \bar{f}_i)$, $(f_i 0)$.

Convert according to these rules the given function (4):

$$\begin{aligned}
 f &= x_2(x_1 \vee \bar{x}_1)(x_0 \vee \bar{x}_0) \vee x_1 \bar{x}_0 \vee \bar{x}_1 x_0 = x_2 x_1 x_0 \vee x_2 x_1 \bar{x}_0 \vee x_2 \bar{x}_1 x_0 \vee x_2 \bar{x}_1 \bar{x}_0 \vee x_1 \bar{x}_0 \vee \bar{x}_1 x_0 = \\
 &= x_2 x_1 x_0 \vee x_1 \bar{x}_0 (x_2 \vee 1) \vee \bar{x}_1 x_0 (x_2 \vee 1) \vee x_2 \bar{x}_1 \bar{x}_0 = x_2(x_1 x_0) \vee 1(x_1 \bar{x}_0) \vee 1(\bar{x}_1 x_0) \vee x_2(\bar{x}_1 \bar{x}_0) \quad (5)
 \end{aligned}$$

Consequently, the programming function (5) of the multiplexer $(4 \rightarrow 1)$ has been received and the signals of variables x_1 and x_0 are fed to the address inputs of witch one.

In fig. 5 it's constructed the functional scheme of the programmed multiplexer in the graphical editor of the automated design system (CAD) MAX + PLUSII which is an integrated environment for the development of digital devices based on ALTERA programmable logic circuits (FPGAs) [2]. It consists of eight chips: three inverters NOT, four three-input logic elements AND and one four-input logical element OR, has two address inputs, four information and one complementary output.

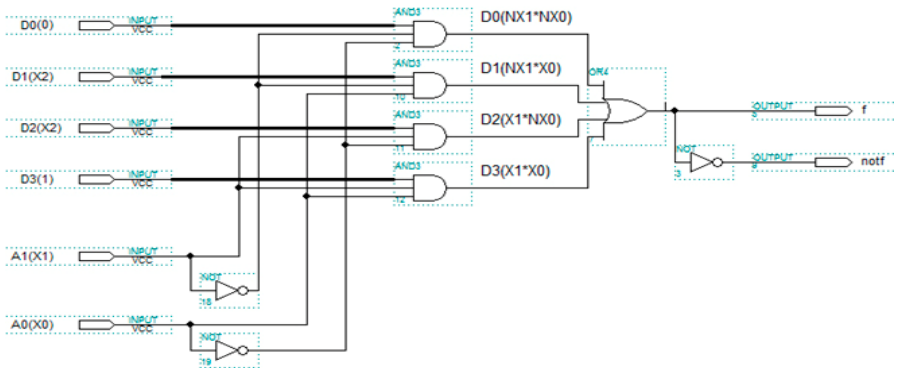


Fig. 5. Chip of the programmed multiplexer

Next, we synthesize a single-electron microscope multiplexer $(4 \rightarrow 1)$ on quantum automata (QA) (Fig. 7).

The principle of QA based on quantum tunneling and coulomb electron interaction allows the creation of devices that can operate as commuting transistors, but with smaller sizes and lower power consumption. A homogeneous QA architecture can be formed using electronic lithography [1,3].

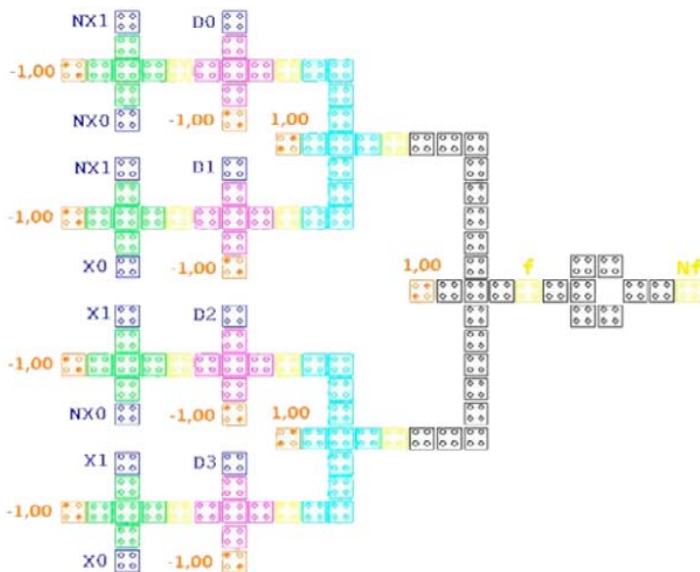


Fig. 7. Nanoscheme multiplexer on quantum automata

Conclusions. The micro- and nanoscales of the reprogrammed multiplexers for the implementation of logical functions have been developed in this work. Programming of the multiplexer was performed using CAD MAX + PLUS II and CAD QCA Designer. Time charts of programmed multiplexers in different environments coincide with the truth table.

A fundamentally new feature of nanoelectronics is due to the fact that the quantum effects begin to dominate for the elements of such dimensions. The electronics, which uses quantum effects, is the basis of a new, so-called nanoheterostructural electronics.

References

1. Melnyk O.S, Todavchich SV Synthesis of programming of nanoelectronic add-ons // Elektronikaisistemi control. - 2013. - № 35. - p.89-94.
2. Steshenko V.B. FPGA firm ALTERA: element base, design system and hardware description languages. - Moscow: Izd. house. "Dodeca- XXI", 2007. – 576p.
3. Walus K. QCA Designer: A Rapid Design and Simulation Tool for QCA // Int. Journ. of Nanotechn. and Appl. - 2005. - V.2, - No.1 - p.1-7.