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IMPROVEMENT OF THE COMMUTATION SYSTEM FOR A MOBILE ROBOT PLATFORM USING POLYIMIDE STRUCTURES

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Introduction. Today, mobile robotics plays an increasingly important role in our lives and in various sectors of society. Currently, much attention is paid to the development of robotic systems with high adaptability to movement along complex trajectories and surfaces. However, the development of these systems is still a rather laborious process, which in turn makes them imperfect and dependent on the environment and other factors that may affect their operation [1-2].

One of the main trends in the device-making technology development is the transition from traditional equipment to electronic means on flexible substrates as part of the flexible hybrid electronics development around the world. In the electronic products microminiaturization conditions, the use of flexible printed structures (FPS), which include flexible electronic components, flexible electronics, printed circuit boards and interconnect elements, provide several advantages in creating both stationary and movable structures [3-4].

Thus, the replacement of rigid hardware components with flexible ones to improve their quality, functionality, reliability and reduce weight-size parameters (WSP), manufacturing labor intensity, cost, as well as the development of tooling based on flexible structures, are currently relevant [5-6].

Aim. In the components of flexible hybrid electronics the film dielectric materials, flexible electronic components and movable microsystem devices designs [3], flexible and flex-rigid multilayer printed circuit boards and cables are used [7-8].

In this application, they allow solving the denser equipment nodes arrangement issue, reducing the WSP of interconnections [5].

Varieties of polymeric materials are used as the FPS dielectric base: polyesters, in particular polyethylene terephthalate, polyimide, fluoropolymer films, liquid crystal polymers, and even thermoplastic films, such as polyethylene, polyvinyl chloride, etc.

For FPS of most electronic devices groups, the polyimide is used that is a high-temperature polymer. Due to the use of polyimide structures in the robotic platforms modernization, their commutation system will have greater chemical resistance, high strength, resistance to corrosion processes and good insulating parameters of the printed circuit boards and cables bases [4, 6-8].

Therefore, the subject of research is the commutation system based on flexible polyimide structures for a mobile robotic platform.

The research purpose is to analyze the flexible polyimide structures as part of mobile robotic platforms using their parameters modeling.

Materials and methods. Mobile robotic systems are distinguished by the presence of a moving chassis with automatically controlled drives [9-10]. They can be wheeled, walking, wheeled walking and tracked. There are also floating and flying mobile robotic systems. Often mobile robots have manipulators, thanks to which they can be used for the military, medical or agricultural industries, in space flights, industrial enterprises, as well as in construction and transport [11-14]. At manufacturing enterprises, the object of robotics is the creation of automatic carts (robocars) moving in the workshop according to a given program when controlled from a computer. The program can be easily reconfigured. Mobile robotic platforms can also include on-board computers with FPS.

In this article the commutation system modernization for the mobile platform Keyestudio 4WD BT Robot car V2.0 is considered. The Keyestudio Bluetooth Mobile Robot is a tutorial development system based on the Arduino controller on the ATmega-328 microcontroller as the core. It has the functions of line tracking, collision avoidance and interference avoidance, IR remote control, Bluetooth remote control, and interference distance measurement and tracking. There is also an LED matrix to display different symbols or robot emotions. A visual programming system is also available. In *Fig. 1, a* the commutation connections diagram of a mobile robot is presented.

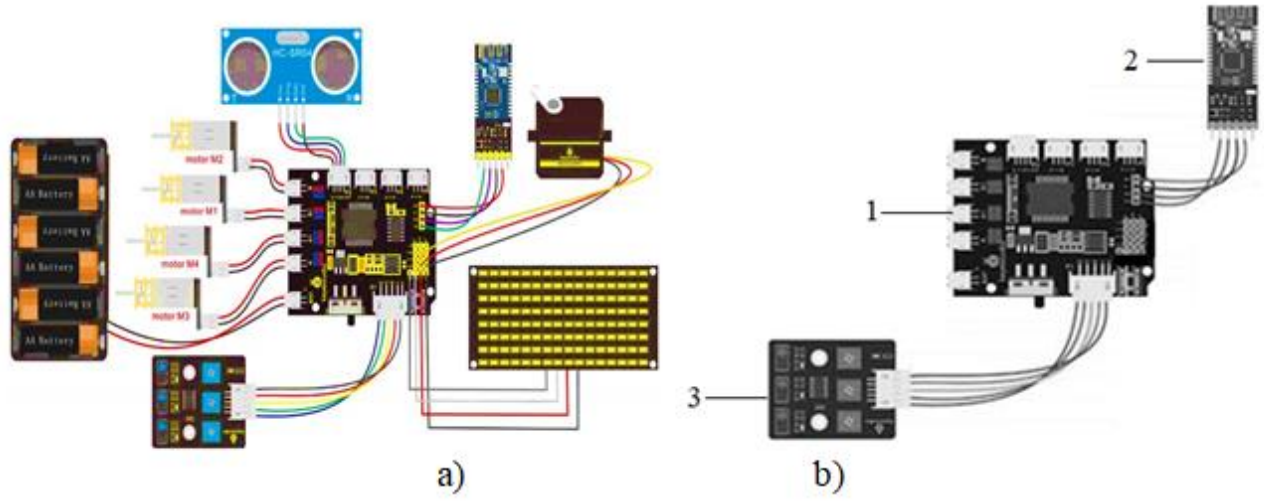

Fig. 1. Wiring diagram for Keyestudio 4WD BT Robot car V2.0 mobile platform

The modernization of this commutation system is carried out based on the replacement wires for connecting rigid printed circuit board *1* (Keyestudio Motor Driver Shield module) with boards *2* (Keyestudio HM-10 Bluetooth-4.0 module) and *3* (Keyestudio Line Tracking Sensor module) shown in *Fig. 1, b* by flexible cables made of polyimide PM-A with a thickness of 100 μm.

The material has good physical characteristics, there is a preservation of elasticity in a wide temperature range [15-17]. The base is oil-resistant, insoluble in organic solvents, moderately resistant to acids and alkalis, has a high radiation resistance.

In the commutation system under study, we use connectors XF2M with 10 pins and pitch of 0.5 mm manufactured by OMRON to connect polyimide cables with rigid boards. The connectors of this series provide reliable cable fixation and resistance less than 100 mΩ (<80 mΩ typical). The contacts of the connectors are protected from oxidation by a gold layer with thickness of about 0.12...0.15 μm over a nickel coating of 2 μm.

Results and discussion. A model of the commutation node for the Keyestudio 4WD BT Robot car V 2.0 mobile robot, upgraded with the use of polyimide FPS, was built in the COMSOL Multiphysics environment (*Fig. 2*).

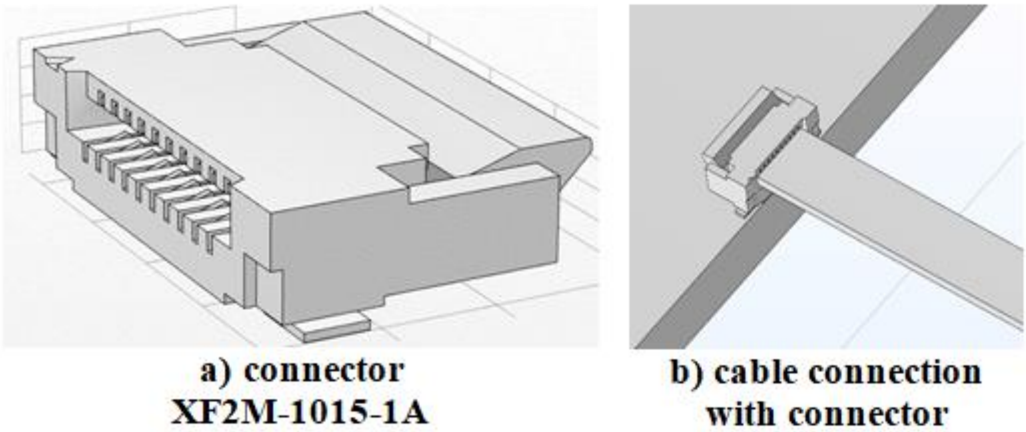

Fig. 2. Simulation model of the commutation system of a mobile robotic platform

The AC/DC Module in COMSOL Multiphysics allows to create models of electrostatic systems with different combinations of 1D-wires, 2D-shells, and 3D-solids. This is possible by using technology based on the boundary element method (BEM). BEM can be used as an independent solution technique or in combination with the finite element method.

The investigated flexible cable is a system of copper conductors formed on a flexible dielectric film.

The electric current level in the FPS and the electric fields distribution in the conductor and dielectric structure layers were studied (*Fig. 3*).

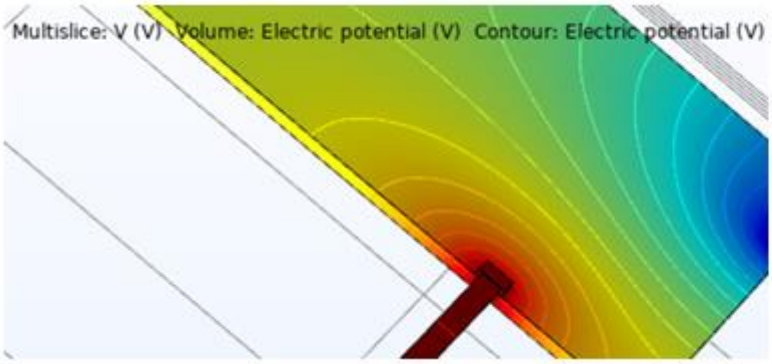

Fig. 3. Current conservation law with respect to the flow V

In this study, a voltage of 5 V and a constant current of 20 mA are set, then the voltage movement from the XF2M connector along the flexible cable to the second XF2M connector is set. As the result, there is a distribution of electric current: red color corresponds to a high positive distribution of current and blue color – to high negative current distribution.

Conclusions. Recently, technology has been moving from the traditional design of rigid electronics to the future of flexible form factors. The flexible technology development offers new functionality through flexible product design that was not previously possible.

Thus, based on the modern design solutions analysis results of mobile robots for various purposes the commutation system for the Keyestudio 4WD BT Robot car V2.0 robotic platform was upgraded using polyimide structures. In particular, the selection of components was carried out and the commutation connections scheme was developed. The commutation system simulation was carried out, namely, the study of the commutation node design connections for mobile robot was carried out using the COMSOL Multiphysics environment.

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