

# **Kinematic analysis of hybrid redundant macro-micro robots with a closed five-link structure – a forward problem of kinematics (FPK)**

**Имена и адреси на авторите**

**Abstract** (100-200 думи )

**Ключови думи** (до 6 думи)

## **INTRODUCTION**

The design and development of micro-actuators such as piezoelectric, electropolymeric and others [1-4] resulted in the design of a new generation of manipulators and robots for extremely precise micro-manipulations [5,6]. Atomic precision was attained which will allow for more complete and profound studies in the field of molecular biology, medicine, atomic physics, etc. Based on piezo-actuators a local module was designed with three and six degrees of freedom (DOF) [7]. However, the problem of combining the macro- and micro-robots has not been solved yet, which is indispensable technologically. A macro-operation requires a large operational space to be performed and high speed to attain maximum efficiency, while the precise micro-motion finalizes the operation. Currently, there are two possible approaches: a mechanical addition of macro- and micro-robots where, of course, the micro-robot is linked to the end effector of the macro-robot, and incorporation of micro-actuators in the traditional mechanical system. An attempt of such hybridization was performed by Wingert in a 6-legged walking insect robot.

The present paper provides an idea of symbiotic combination of a macro-manipulation system with micro-actuators so that in a certain sequence and motion planning the desired operation is performed with no warranty of atomic precision. A serious problem with such a solution is keeping the high accuracy of the micro-operation. The authors provide a possible solution by redundancy of the manipulation system (MS) for micromotions. The proposed MS has a closed five-link kinematic chain (KC) like the robots protected by US patents 2060556 and 0200105. In the publications of Kobayashi, E. et al. [8,9] there are realized robots described having an analogous five-link structure for laparoscopic operations. The structure of the latest series of robots „SCARA” – RP-AH” is analogous, their plane of operational space being horizontal. The translation motion is performed by the last link joined to the end effector by an axis overlapping that of the hinge B (fig. 1, 2). The publication also contains the conditions for synthesis of a double-crank five-link KC, an algorithm for finding the transfer functions (TFs) of micro-actuators, necessary for the strategy building and control performance, as well as an algorithm for single-direction of macro- and micro-motions at the end of the first one and in the beginning of the second one. The aim is single-directed compensating for windage in the MS, which can be attained thanks to redundancy.