

# Analysis of Automation Processes of Printed Circuit Boards Manufacturing Equipment

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**Abstract**— In this article, the authors present a process of the printed circuit boards manufacturing equipment simulation model design. The model was used to create, optimize and test the movement control subsystem of the device.

**Keywords**— automation; simulation model; PID controller; optimization; movement control.

## I. INTRODUCTION

The development and implementation of automated hardware and software of whole the printed circuit boards (PCBs) manufacturing process significantly shortens the timeframe and reduces the risks during designing and implementing of new electronic devices [1,2]. These tools give us a possibility to automate the development of electronic devices, including schematic diagram and simulation, circuit board layout, image processing, and circuit board fabrication by milling, surface mounting of a radio-electronic component on a circuit board[3,4].

## II. SIMULATION MODEL DESIGN

The equipment consists of two precision mechanical 3D modules with digital DC servo drive control systems. Mechanical modules are distinguished by drive actuator nodes. For precision engraving, a high-speed micro-milling drive is used. Surface mounting is carried out by a specialized device with vacuum capture and retention of radio components.

The mechanical part of the system was designed in SolidWorks™ CAD software environment. Using the SolidWorks software environment, technical details of the equipment were developed, simulations and virtual technical tests of the solid-state model of the system were carried out.

The developed CAD model of the mechanical module was imported into the SimScape Multibody™ environment along with information about mass, inertia, connections, constraints, and 3D geometry of the imported models (Fig. 1).

The package allows us to form and calculate motion

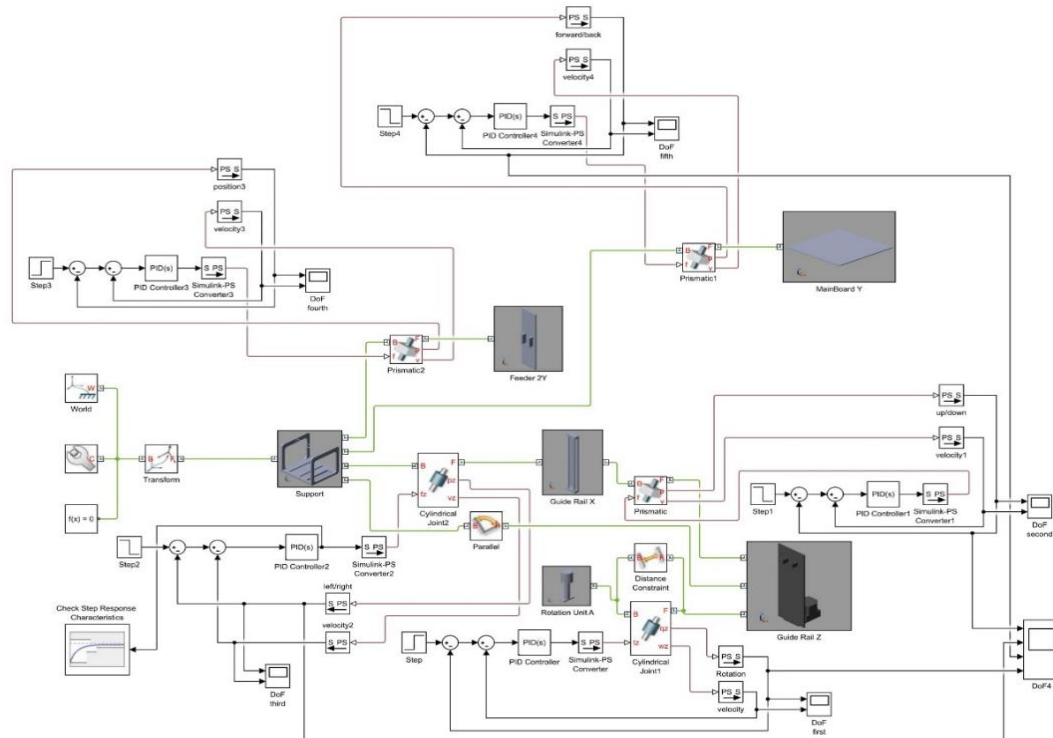


Figure 1. Simulink simulation model of the control system for surface mounting of radio components

equations for a complete 3D mechanical system. In the simulation, blocks representing moving parts of mechanical modules, their connections, constraints, force elements and sensors were used. Simscape Multibody can automatically generate 3D animation to visualize the dynamics and simulate multi-body mechanical systems.

The environment also allows us to parameterize the model using MATLAB variables and expressions, and create a model for the Simulink automatic control system. It is possible to integrate hydraulic, pneumatic, electrical and other systems into the model using Simscape™ related products and explore the system in a single simulation environment.

All movement control systems are based on PID controllers with feedback on the position and speed of the drives. An optical incremental encoder in the feedback loop serves as the rotation sensor. This model includes a digital control system for the power and mechanical parts. As a result, the transverse characteristics of the movement and speed of actuators (Fig. 2) and the optimal tuning of the PID controllers were obtained.

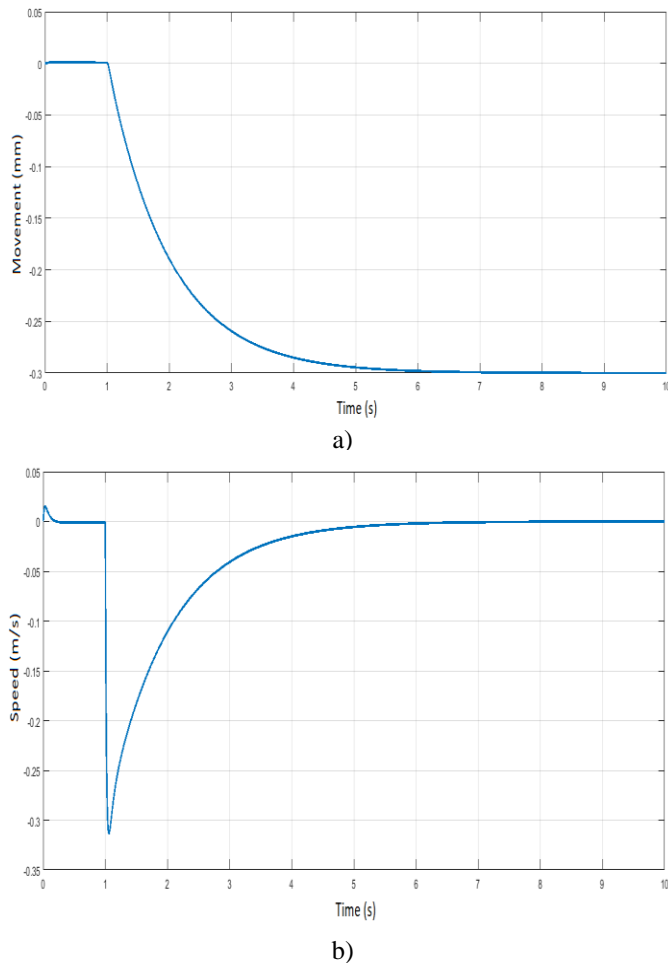


Figure 2. Transitional characteristics of the X-axis movement control subsystem: a) by movement, b) by speed

As we can see, controller with optimized tuning parameters can provide high positioning speed with high accuracy at the same time, without overshooting. Successive tests on real hardware confirmed these results during the PCB assembling process.

Such a model gives us an opportunity to develop, test and optimize movement control systems for such printed circuit boards manufacturing equipment without using the real hardware. What is more, we could easily adapt our model to a new mechanical design by changing the parameters of its parts.

The CircuitCam software is used in the PCB layout process. Data from any automated PCB design system, such as P-CAD, can be imported, properly processed by CircuitCam and transferred to a program that directly converts to G-CODE and controls the process equipment.

Another advantage of CircuitCam software usage is that it also handles PCB drawings in P-CAD. The program calculates the contours around all printed conductors. Subsequently, only narrow insulating circuits around each conductor are to be milled. This method provides higher quality and density of conductors than chemical etching of boards [5].

### III. CONCLUSIONS

The operation of the automated complex can significantly reduce the production time of layouts of printed circuit boards. Reduce the routine work of employees of a technical firm, increase productivity. Installation of all SMD components on the PCB is done automatically, which virtually eliminates installation errors. This increases the flexibility of production, reduces the time for the introduction of new devices. The developed simulation model could be used in future to develop, optimize and test movement control systems for such a PCB manufacturing tools with different geometry, mass or even structure parameters.

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