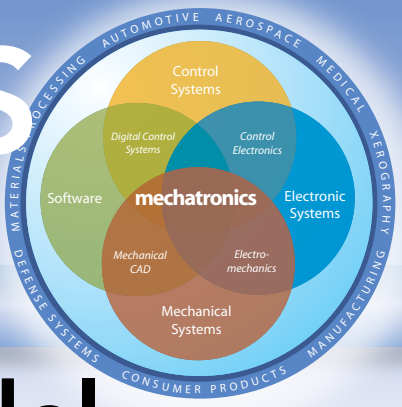
MECHATRONICS IN DESIGN

FRESH IDEAS ON INTEGRATING MECHANICAL SYSTEMS, ELECTRONICS, CONTROL SYSTEMS AND SOFTWARE IN DESIGN



Choosing the Right Model

In past columns, we've discussed the essential role of modeling in mechatronics. Now, let's look at your options in designing a flexible actuator suspension.

This design involves a concept for a pick-and-place device for mounting chips on a printed circuit board (Figure 1). To evaluate this concept early in the design process, we initially neglect the motor electrical dynamics, the compliances of the timing belt, spindle and carriage guidance, the friction in the system and any nonlinear and parasitic effects. We then construct a low-order dynamic physical model (Figure 2), which takes into account only the rigid-body mode and the lowest mode of vibration, in this case from the frame mounting.

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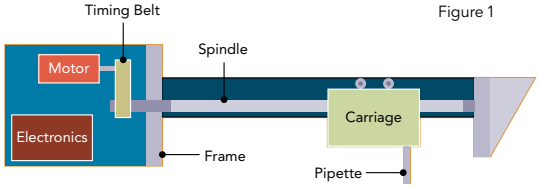
The system has one input — motor torque — and two outputs, actuator position Θ and end-effector position x_e. Linear movements of the end effector m_e are a combination of movements due to actuator rotations and frame vibrations. This model is a good basis to provide reliable estimates of the dominant dynamic behavior of the concept.

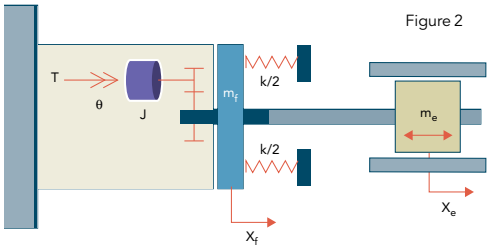
Figure 1



Pick-and-place device for mounting chips.

There are three approaches for deriving the mathematical model for this physical model: block diagram, linear graph and bond graph. The block diagram approach requires you to draw free-body diagrams and apply Newton's Laws. Resulting equations can then be represented in block-diagram form. The bond graph (Figure 3) and the linear graph (Figure 4) approaches give us the mathematical model directly from the graphical representations. All three methods give the correct state-variable equations of motion.

Figure 2



Low-order dynamic physical model.

To better understand all these methods, I contacted Professor Donald Margolis, UC Davis, co-author of "System Dynamics: Modeling and Simulation of Mechatronic Systems" and a bond graph expert and Professor Derek Rowell, MIT, co-author of "System Dynamics: An Introduction" and a linear graph expert. They both offered valuable insights on their approaches and their books are essential for every practicing engineer. My colleague, Professor Mark Nagurka of Marquette University, also has experience with these approaches and provided additional information. Based on these discussions, we'll be posting a longer article on these modeling methods on *Design News*' website (http://rbi.ims.ca/5697-531).

With this article, we conclude our emphasis on the key role of modeling in mechatronics and the importance of science and mathematics in the practice of mechatronics. Future articles will focus on mechatronic success stories and state-of-the-art mechatronic applications illustrating the value of what I have been preaching.

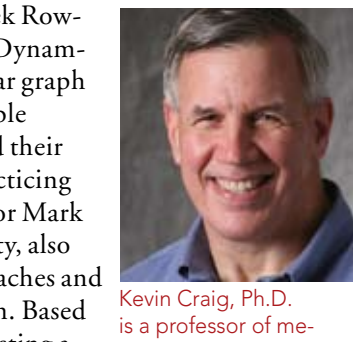


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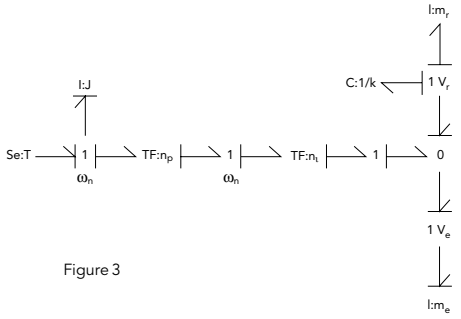
Figure 3



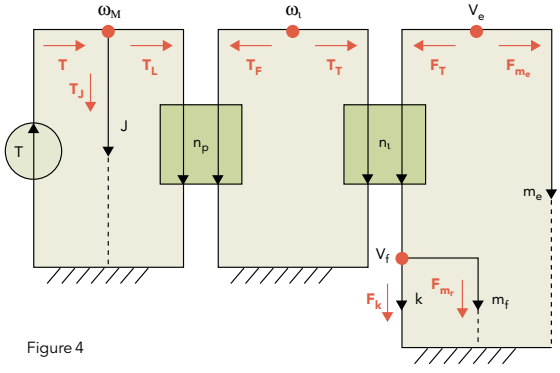


Figure 4

The bond graph, above, and the linear graph, left, give a mathematical model of the chip-handling device.

Learn from other state-of-the-art mechatronics' applications at the Mechatronics Zone: http://rbi.ims.ca/5697-532