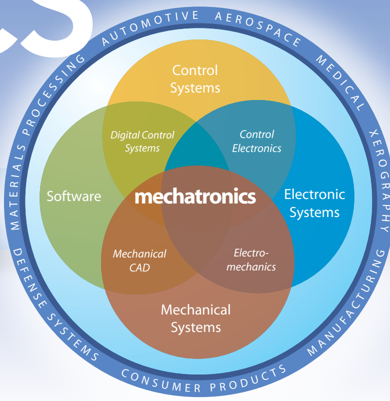
MECHATRONICS IN DESIGN

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



Testing the Tools

BY KEVIN CRAIG

Like many of you, I have played golf off and on since I was a teenager. It always seemed like it should be an easy game. But as anyone who has played golf knows, that is the furthest thing from the truth. I now believe the problem with learning how to play golf is the same problem engineers face when they try to solve a problem by building and testing without first using science and mathematics to model and understand.

Solving engineering problems without using fundamental science and mathematics is like trying to play golf without a good understanding of what you are trying to accomplish, as well as the fundamental golf mechanics that can yield that mysterious feel or groove we all try to achieve on the golf course. All expert golfers for more than a century have looked the same at impact with the ball. For a right-handed golfer, that means a flat left wrist, a bent right wrist and hands ahead of the ball with a forward-leaning shaft. During the downswing, the club shaft stays on plane until well after impact. Anything one does in golf that does not guarantee these results is a waste of time and may sometimes work and sometimes not. I often feel cheated that I did not understand that earlier in my life.

This is not a golf instruction column, but I use this analogy to emphasize that engineers today do not have to feel cheated and can design with confidence if they rely on a process grounded in science and mathematics. That method will always lead to a successful conclusion if performed diligently.

In previous columns, I have presented tools for developing a mathematical model from a physical model: block diagrams, bond graphs and linear graphs. Linear graphs and bond graphs, which are graphical representations of the physical model, will generate the equations of motion directly. Representation in block-diagram form requires one apply the laws of nature directly to the physical model, perform detailed analysis and then represent those equations graphically in a block diagram.

We need a relevant engineering example to evaluate these alternatives. In my first column at the beginning of the year (http://rbi.ims.ca/5411-531), I referenced a concept for a pick-and-place device for mounting chips on a printed circuit board (Figure 1, below, left). 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. A low-order dynamic physical model of the system (Figure 2, below, right) takes into account only the rigid-body mode and the lowest mode of vibration, in this case from the frame mounting.

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 has a small number of parameters, completely describes the performance-limiting factors and is a good basis to provide reliable estimates of the dominant dynamic behavior of the concept. After four free-body diagrams and several pages of analysis, I am able to write the transfer functions between the input and outputs. The bond graph and linear graph approach should give us the mathematical model directly from the graphical representation. In the next article, we will put these two approaches to the test.

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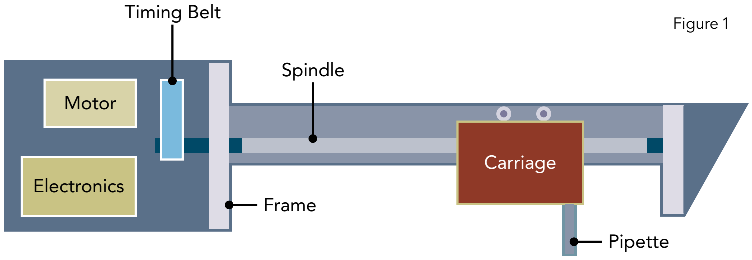
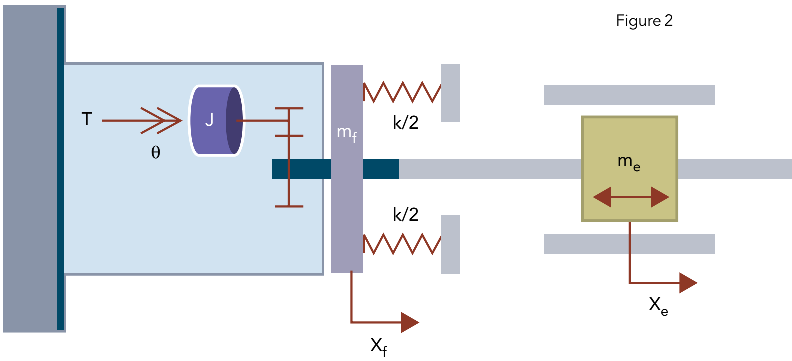


Pick-and-place device for mounting chips on a printed circuit board.



A low-order dynamic physical model for the pick-and-place design takes into account only the rigid-body mode and the lowest mode of vibration, in this case from the frame mounting.

To see other mechatronic system designs put to the test, check out Kevin's webcast at: http://rbi.ims.ca/5411-532