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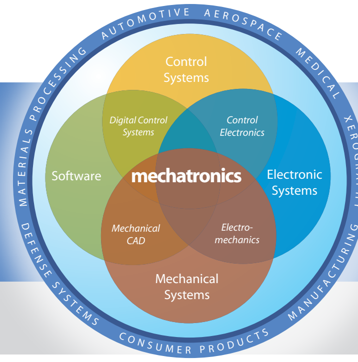
MECHATRONICS IN DESIGN

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



Control-Oriented Modeling for Backlash

Backlash is complex; its model for control design is not.

IN EVERYDAY LANGUAGE, the word backlash sounds as undesirable as its meaning; i.e., a strong adverse reaction or a violent backward movement. In engineering, the situation is no different. Backlash, the excessive play between machine parts, as often occurs in gears and flexible couplings, is highly undesirable and usually exists with compliance. It gives rise to inaccuracies in the position and velocity of a machine, as well as to delays and oscillations.

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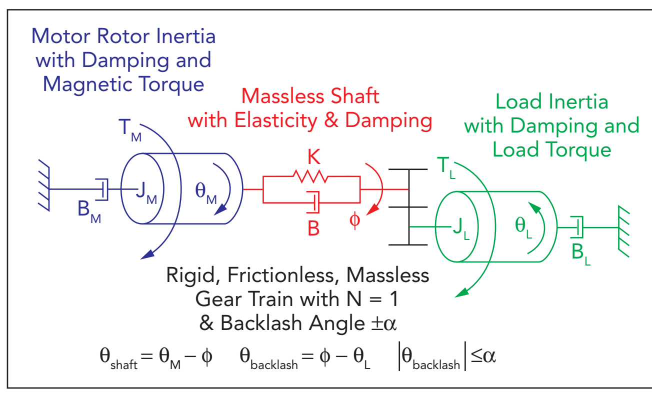
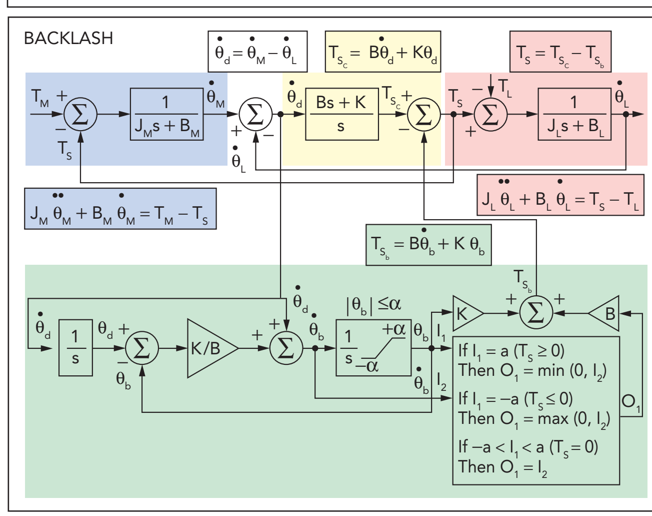
For any physical system, there is a hierarchy of models possible, from the most real, most complex, less easily solved, to the less real, less complex, more easily solved. The model that is most beneficial for control design is the least complex model that still retains sufficient accuracy to capture the gross dynamic behavior of the system. It is critical to strike a delicate balance between dynamic complexity and accuracy in the model.

The diagram shows the physical system under investigation with the accompanying assumptions. In addition, we assume that collisions due to backlash are sufficiently plastic to avoid bouncing. It is critical that the model capture the fact that the output from the backlash element is a torque on the load inertia, not a displacement of the load inertia. The model presented here also captures the situation where the assumed massless compliant element has damping (see survey paper by Nordin and Gutman, Automatica, 2002: **http://dn.hotims.com/34940-504**). The importance of this can be demonstrated as follows: Imagine you are compressing with your hand a massless spring that possesses no internal damping. If you were to suddenly move your hand away, the spring would stay in contact, as its response is instantaneous, since, being pure, it has no mass or damping. But if the spring has damping and you repeat the experiment, the spring's response would not be instantaneous and it would start to lose contact. The model shown in the block diagram, developed from the system equations of motion, captures these essential attributes and fosters insight. It can be implemented in MATLAB/Simulink easily, and can be used most effectively for control system design. **DN**





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