Robotic Arm System

A robotic system can be modeled using a state-of-the-art cosimulation feature in ANSYS® Simplorer® that enables direct linking to the rigid dynamics solver within ANSYS Mechanical™. This transient-to-transient link allows engineers to combine detailed rigid mechanics models with power electronics, electric servo drives and control system models in one simulation environment. Advanced analysis capabilities can then determine the dynamic response of an assembly of rigid bodies linked by joints, such as a robotic arm or a crankshaft system.

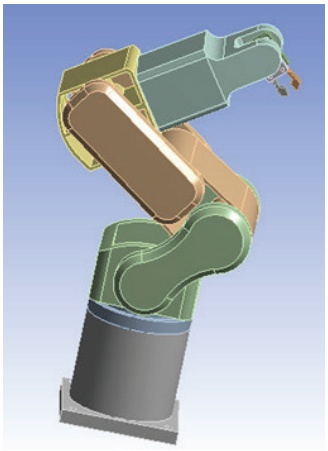

Figure 1. Robotic arm system with five revolute joints

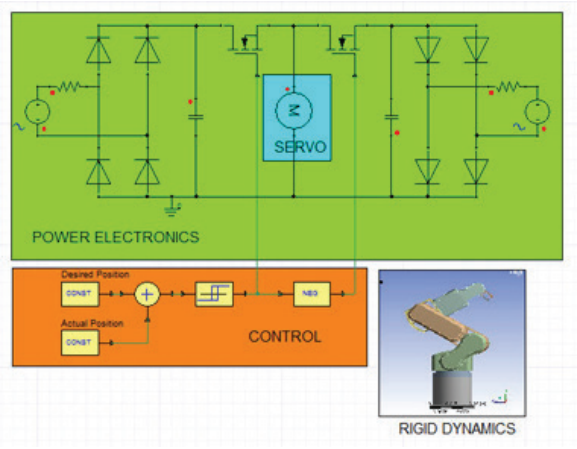

Figure 2. ANSYS Simplorer schematic shows power electronics, servo and control subsystem models together with the rigid dynamics. This represents the 3-D robotic arm system assembly.

Products Used
ANSYS Simplorer, ANSYS Mechanical

Keywords
Robotic system, rigid body dynamics, power electronics, control systems

Robotic Arm System Model
There are at least three subsystems in a robotic arm system: One incorporates the power electronics used to power actuators (servos) that drive the arm's motion; a set of controllers comprises another control subsystem, ensuring that the arm moves as required; and the third is an assembly of rigid bodies linked by joints (a rigid body dynamics subsystem).

Ordinarily, whole-system simulation in ANSYS Simplorer consists of detailed power electronics, actuator and control system models together with a simplified rigid body model, represented as a load using a simple equation or block. A standard rigid dynamics solution in ANSYS Mechanical concentrates on the motion of bodies that move rigidly in 3-D space, without any regard to driving power electronics or control systems. However, the rigid dynamics cosimulation feature in ANSYS Simplorer allows you to combine these three (and more) subsystems into one complete simulation. The traditional (simplified) load model is replaced by a true 3-D model of an entire assembly, represented as a rigid dynamics block directly on the ANSYS Simplorer schematic capture. Power electronics and control systems directly influence the rigid bodies' motion, and the feedback of motion dynamics on power electronics and controls is also simulated.

In the robotic arm system in Figure 1, the individual parts are linked by five revolute joints, so each arm can rotate with 1 degree of freedom around a designated axis of rotation. The motion of each part is achieved using a servo drive with its own control system, according to the prescribed trajectory. The model of the entire system (including five servo drives) was prepared in ANSYS Simplorer. Figure 2 shows the model of one of the servo drives. The power electronics subsystem (green rectangle) consists of AC sources, diode rectifiers and power MOSFETs that provide energy for a servo drive (blue rectangle). The switches are triggered at appropriate instances by control signals generated using the control block (diagramed in the orange

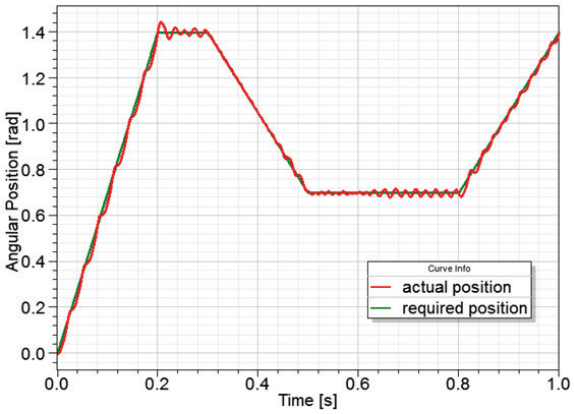

Figure 3. Actual rotational position compared to required position for one robotic arm, determined by ANSYS Simplorer model that employs cosimulation with ANSYS Rigid Dynamics

rectangle). The rigid dynamics model of the whole robotic assembly was prepared in ANSYS Mechanical using the Rigid Dynamics solver. This model is then linked to ANSYS Simplorer and placed as a block on the ANSYS Simplorer schematic. Figure 3 shows the required position (green) for one of the moving parts and the actual simulated position (red). Note the small oscillations about the required position, corresponding to the controller action and switching of the transistors.

Summary

ANSYS Simplorer provides design engineers with an integrated simulation platform well suited to evaluate the performance of an overall system that includes power electronics, sensors, actuators, controls, robotic arms and other device components. Each system part can be represented by a simpler or more detailed model. Cosimulating rigid dynamics with ANSYS Simplorer provides a high-fidelity 3-D rigid body model of a robotic arm assembly to enhance simulation accuracy.

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