SynqNet® Case Study

Corrective Laser Eye Surgery

VISX was founded in 1986 and began with a series of experiments under the premise that shaping the surface of the eye with a excimer laser might have the same effect as corrective lenses. By the mid 1990's VISX lasers were used in over 40 countries worldwide. Fast forward to 2003, and VISX is the world leader in corrective laser eye surgery. VISX utilizes SynqNet motion technology for precision lens control in several laser eye surgery machines made by the company.

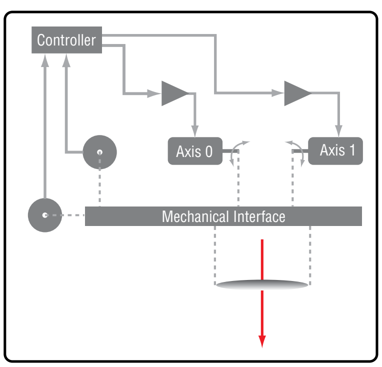
Application Overview

Inside each VISX Refractive Laser System is a laser, an optical delivery system, and a control system. After the laser beam is generated, it is shaped by moveable optical elements, and it is steered by a movable lens. The moveable optical elements, and the movable lens are controlled by six precision servo motors. The lens that steers the beam is controlled by two of the six precision servo motors attached to the laser beam steering mechanism. The movable optical elements and the laser beam steering mechanism utilize precision encoders for position feedback. The SynqNet motion controller is then responsible for laser beam shaping and steering in the process.

Motion Control

The SynqNet motion controller sends an appropriate output value to each amplifier that drives each servo motor based on a predetermined motion trajectory. The SynqNet controller then accepts position values from a sophisticated vision system that scans the laser beam across the eye, providing the proper laser refractive treatment. The resulting motion generates signals from each encoder that are sent back to the controller.

The encoder signals are "captured" by the FPGA on-board the SynqNet controller. For each axis, the position can then be updated and a new trajectory calculated by the DSP every firmware cycle.

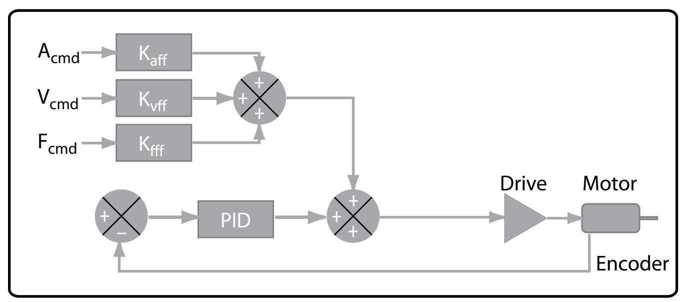


Basic Lens Control Diagram

The resulting time between moves is 15ms. Since the FPGA can process data much faster than the DSP clock cycle, position capture and compare using an FPGA allows greater flexibility in triggering events and processing critical events in any application.

PID Closed Loop Control

The control loop uses PID gains optimized to the 6-axis system. Testing and developing the appropriate PID values was accomplished with MotionConsole™, a motion utility offered by Danaher Motion. Motion Console provides a GUI to input a wide range of motion parameters to exercise axes and aid in finding the right gains for optimal performance. This closed loop approach provides the safety and reliability that VISX demands in every machine. In addition, the vision system that closely monitors the patient can abort any action should the patient unexpectedly move during a procedure.



PID control loop with feedforwards

Fast Settling Time

Another key application feature is fast settling time after each commanded position. This simply means that once the controller sets a position, there is tight servo control to the actual position with minimal overshoot. The use of feedforwards in the PID loop also helps to decrease settling times. By implementing friction, velocity and acceleration feedforwards to the PID control loop, settling time is reduced by using a simulation of the system to make better commands to the amplifiers. PID control is based on error feedback, whereas feedforwards are predictive command modifications to improve motion performance.

VISX® SynqNet®

www.visx.com
+1.800.246.VISX

www.synqnet.org
info@synqnet.org
+1.805.879.0579