Motors Take on Cancer

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The Project: A multi-leaf collimator device needed to offer greater levels of accuracy than any similar product on the market.

The Solution: Multiple devices were incorporated, including 180 motors, to shape gamma ray radiation therapy beams, controlled by one interlinked motion control system.

When it came to designing a multi-leaf collimator (MLC) device, ViewRay [1] took on the challenge to produce an end product that would be more accurate than others on the market. ViewRay collaborated with Maxon Precision Motors [2] for critical components, including a custom motherboard, motors, encoders, gearheads, and individual motor control modules, according to an engineering team member.

ViewRay Incorporated is a privately held medical device company developing advanced radiation therapy technology for the treatment of cancer. The ViewRay system provides continuous soft-tissue imaging during treatment, using MRI-guided radiotherapy, so that clinicians are able to see where the actual radiation dose is being delivered and adapt to changes in the patient’s anatomy.

Overall, the ViewRay system includes five sub-systems, which are seamlessly integrated to provide optimal patient care. The major subsystems are: real time MR

imaging, treatment planning, dose prediction and optimization, real time soft-tissue targeting, and remote review and approval. The treatment delivery is performed in a split-magnet MRI system with rotating gantry assembly to position three shielded Cobalt-60 sources with the three multileaf collimators.

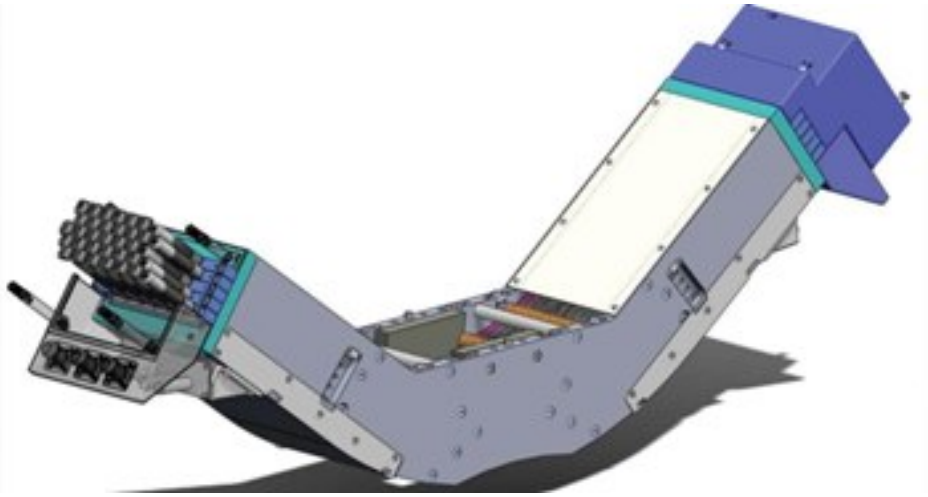
The imaging in other radiotherapy technologies took place before or after treatment, not while the beam was on. This was a limitation in providing therapy because targeting could not be adjusted dynamically. Soft-tissue motion often allowed a tumor's position to shift during treatment, causing soft tissue damage.

The ViewRay system solved this problem by using a combination of MR imaging and radiation therapy delivery technologies. With continuous soft-tissue imaging, during treatment and with the beam on, ViewRay tools can refine the target and re-optimize the dose while the patient is on the treatment table. This was the first MRI-guided Radiotherapy System produced.

According to the engineering team, "The MLC motor control system is a critical portion of the system. We knew it would also be one of the more challenging to design because of proximity to the MRI magnet, and volume constraints due to the gantry configuration." The system uses three gamma ray sources, mounted in separate shielded heads. For ViewRay, the double-focused MLC is designed to sharpen field edges to produce penumbra comparable to conventional accelerators, so that clinicians can treat patients with greater confidence.

The team chose Maxon's EPOS2 Module 36-2 compact digital positioning controllers for their small form factor, which allowed them to package 60 channels of motion control for each collimator. Thirty modules can fit on a single custom motherboard, and there are two motherboards per collimator. Each ViewRay system required three of these collimators, one for each of the three heads used in the system.

EPOS controllers are compact, fully digital, smart motion controllers designed for use as plug-in modules in customer-specific motherboards, and can be used for single-axis or multi-axis motion control systems. Each EPOS module implements a flexible and highly efficient power stage, and drives a brushed DC motor with digital encoder. They are especially designed to operate as a slave node in a CANopen network. They have a maximum current output capability of two amps, running from an eleven to thirty-six volt DC power supply.



In order to interface with the controllers, the ViewRay team used the resident EPOS2 firmware, which provided simple to implement operating modes and monitoring functions required by the control system. What made things easier was that the controllers are CANopen compatible, which allowed the design team to define up to 127 device addresses on a single bus segment.

Each of the collimators contains sixty leaves that are arranged in two opposing banks of thirty. Since there are three collimators, the device uses 180 EPOS controllers as well as 180 motor/encoder/gearhead assemblies. The MLCs are mounted on the gantry system to provide collimation of the three gamma radiation sources with respect to the target. While the gantry is moving into position, each collimator leaf is positioned according to the treatment plan. To position each leaf, CANopen bus commands are directed to the associated node consisting of a motor, encoder, gearhead, and controller. The result is a precisely collimated shape that matches the treatment plan.

The 180 motors used in the system are RE16 brushed DC, 4.5 Watt motors. Each motor operates at speeds up to 11,000 rpm. Along with the motors are MEnc13 Hall-effect encoders for precise motor control and GP16A gearheads with 19:1 reduction, providing adequate torque for positioning speeds of 1.0 cm per second.

The EPOS Studio software package provided an easy-to-learn, easy-to-use development environment for proof of concept and end-product development

activities, according to engineering. Due to MRI magnetic field effects, the MLC controllers had to be remote from the motors, and housed in a convection-cooled chassis.

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Links:
[1] http://www.viewray.com
[2] http://www.maxonmotorusa.com