The control system for the new 100 mm target wheel at TASCA

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A new target wheel system for the gas-filled separator TASCA with a 100-mm diameter target wheel was designed and built. For this, a new motor control system was developed, basically consisting of a stepper motor [1], a stepper motor terminal [2], a control PC [2] and I/O terminals [2] for the input and output signals for the control loop.

The stepper motor terminal [2] is responsible to drive the motor in a controlled way, using a ramp function, up to the required frequency of 2250 revolutions per minute (rpm). The macro pulse signal (50 Hz HEAG signal) is connected to an input terminal and is used to synchronize the motor frequency to the HEAG signal. The exact wheel position (or more precisely the target position during the beam irradiation) is controlled and regulated using the master pulse (beam signal) as an input and the feedback of the wheel position at this time. To determine the wheel position during the 5 - ms long macro pulse signal, (corresponding to the beam pulse) an optical position detection system was implemented. The system uses optical fiber sensors composed of the fiber units and the amplifier units [3]. Holes in the target wheel allow the laser to shine through when the wheel is at an exactly defined position: one set of holes generates a signal every 90° and the other one every 360°. These signals are connected to input terminals and processed for the control loop.

The implemented software [2] control system is based on the design and experience won with a similar system employing a large target wheel containing eight target segments used earlier at TASCA. It was designed and developed using the function principle of the finite state machine model, i.e., with the process being divided into states where each state has its input and output conditions. According to this, the transition to the next state (or if necessary to a previous state) will be given. Each state performs one or more functions required from the system. There is a principal task where this state is running and the additional tasks or subprograms (subroutines) which are called on each state as far as necessary. Defined states are implemented where the user has the possibility to stop the wheel movement; in this case the system will return to the initial state. Control functions are included to detect if there is an error present or if a movement function reports an error. Similar to the stop state, the error state is programmed to stop the axis movement in a very slow way with a ramp function, in order to protect the targets.

The setups required for the wheel movement like motor velocity, acceleration, beam cycle time, offset position from the master signal are preset such that the user is not required to enter these values.

As the used motor frequency of 2250 rpm is outside of the range of conventional stepper motor applications, there is the possibility that the motor fails to follow the rotation field and ends in a standing situation. Therefore a mechanism to detect the motor rotation or standing condition using the signal of the optical sensor system was implemented.

A user interface, divided into two areas was developed; in one window, the “operation window”, the user is allowed to start or stop the movement and gets feedback information like the actual wheel movement status, the frequency of the wheel, if it is synchronous with the beam structure and error messages. The other one, the “service window”, allows the user to change parameters for the synchronization of the master pulse to the target and includes other additional functions for improvements on the system development and maintenance.

The system was successfully tested with 5.5 MeV/u $^{24}$Mg beam, in November 2010. Figure 1 shows an irradiated target wheel containing four tape targets to visualize the beam position. The beam hit each of the four targets at the correct position.

Figure 1: The new TASCA target wheel after a test irradiation with $^{24}$Mg beam.

Figure 2: The complete assembly of the 100 mm target wheel in its cassette.

References