Programmable Logic Controller Program for Current Loop Regulation

Amanda Hoebel, Mary Ann Antonioli, Peter Bonneau, Pablo Campero, Brian Eng, George Jacobs, Mindy Leffel, Tyler Lemon, Marc McMullen, and Amrit Yegneswaran

Physics Division, Thomas Jefferson National Accelerator Facility, Newport News, VA 23606

October 31, 2018

This note describes the current loop regulation program written for the Hall C HMS detector's quadrupole.

The HMS detector's three quadrupole magnets are powered by Danfysik (System 8000) magnet power supplies (MPS). The MPS are controlled by the current regulation loop program (CRLP), which runs on a PLC. CRLP sets the currents *I* [A] to which the power supply ramps and reads back the current.

Two critical sections of the program are the function block and the ladder logic diagrams. The function block diagram takes the input current entered on the PLC's HMI screen and converts it to a format read by the Danfysik power supply. Additionally, the function block diagram initiates the start of the ladder logic program through a Boolean indicator, received from the PLC HMI screen. When this Boolean indicator signals true, the ladder logic evaluates overshoot settings and sends the appropriate commands to the MPS.

CRLP was tested with a Danfysik MPS simulator—developed in Python, specifically for the test. Figure 1 shows test scenarios of readback current $I_r(t)$ and target current $I_{tgt}(t)$, as well as situations in which the target current was changed on the fly during a ramp.

a. $I_r(t_0) < I_{tgt}(t_0)$**:** CRLP ramps up MPS current to overshoot $I_{tgt}(t_0)$ by a specified value input by the magnet expert, and then ramps down MPS current to $I_{tgt}(t_0)$.

b. $I_r(t_0)>I_{tgt}(t_0)$**:** CRLP ramps down MPS current to $I_{tgt}(t_0)$.

c. $I_r(t_0)<I_{tgt}(t_0)\mapsto I_r(t_1)<I^{new}_{tgt}(t_1)$**:** CRLP starts to ramp MPS current to $I_{tgt}(t_0)$. However, at time t_1 and before $I_{tgt}(t_0)$ is reached, $I_{tgt}(t_0)$ is changed to a new target value, $I^{new}_{tgt}(t_1)$, which is greater than the readback value at t_1, $I_r(t_1)$.

d. $I_r(t_0)<I_{tgt}(t_0)\mapsto I_r(t_1)>I^{new}_{tgt}(t_1)$**:** CRLP starts to ramp MPS current to $I_{tgt}(t_0)$. However, at time t_1 and before $I_{tgt}(t_0)$ is reached, $I_{tgt}(t_0)$ is changed to a new target value, $I^{new}_{tgt}(t_1)$, which is less than the readback value at t_1, $I_r(t_1)$.

e. $I_r(t_0)>I_{tgt}(t_0)\mapsto I_r(t_1)>I^{new}_{tgt}(t_1)$**:** CRLP starts to ramp MPS current to $I_{tgt}(t_0)$. However, at time t_1 and before $I_{tgt}(t_0)$ is reached, $I_{tgt}(t_0)$ is changed to a new target value, $I^{new}_{tgt}(t_1)$, which is less than the readback value at t_1, $I_r(t_1)$.

f. $I_r(t_0)>I_{tgt}(t_0)\mapsto I_r(t_1)<I^{new}_{tgt}(t_1)$**:** CRLP starts to ramp MPS current to $I_{tgt}(t_0)$. However, at time t_1 and before $I_{tgt}(t_0)$ is reached, $I_{tgt}(t_0)$ is changed to a new target value, $I^{new}_{tgt}(t_1)$, which is greater than the readback value at t_1, $I_r(t_1)$.

The program performed as expected. Currents reached targeted values and responded correctly to on-the-fly changes of target value.

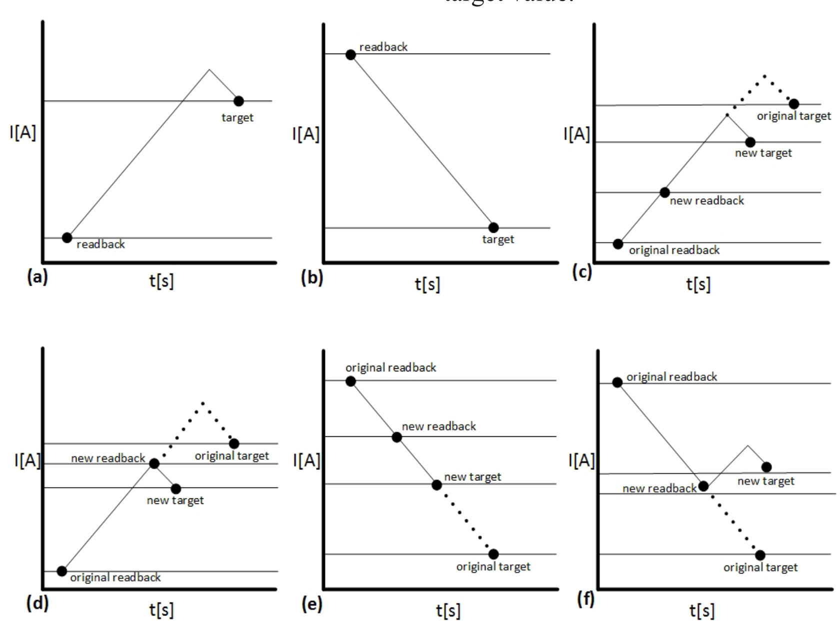

FIG. 1. (a)–(f) show different scenarios of target and readback currents for which the CLRP was tested.