Author:
Mikko Kivekäs mikko.m.kivekas@student.jyu.fi
Last updated: August 29, 2019

PAC-SLI Automation MANUAL

Contents

1 Introduction

This manual cintains information about PAC-SLI implantation station automation. PAC-SLI, Perturbated Angular Correlation of Short Liver Isotopes, is implantation station discussed in this manual is located at ISOLDE @ CERN.

2 Hardware

Short description of used hardware in the system.

2.1 PC

Any PC applies, that has Arduino-IDE, LabVIEW and Trinamic TMCL-IDE. Two available USB-ports are required. This PC runs the LabVIEW automation program and GUI.

2.2 Microcontroller

Used microcontroller is Arduino model Mega2560. Arduino Mega2560 has 52 digital I/O pins and 9 analog input pins and other pins, like voltage supply and ground pins. This microcontroller was chosen over others because of plenty of digital pins and advantage that it has analog inputs. I/O pins work 5 V voltage and outout current is in order of 20 mA. Arduino Mega2560 is powered through controlling PC

2.3 Motorization

Motorization in this system is done by Trinamic QSH4218-35-10-027 bipolar steppermotor and Trinamic TMCM-1070 stepper motor controller. Controller uses TTL communication and is connected to Arduino Mega2560.

Motor is connected to combined encoder plate and shaft coupling that couples it with vacuum feedthrough. Encoder plate is very simple round disk with two holes marking positions. Position informatin is read by photogate.

2.4 Temperature sensors

There is two K-type thermocouples sensing temperature inside the implantation chamber. Thermocouple signal is amplified and digitized by MAX31855KASA+ IC and read by Arduino Mega2560 SPI.

2.5 Power supplies

Two power supplies are powering the system other than microcontroller, that is powered by PC.

First is 24V36W power source for stepper motor controller and cooling fan.

Other is 12V100W source for furnace lamp.

2.6 Furnace

Furnace is quarz filament halogen lamp with shielding. Furnace heats sample to remove lattice defects created in implantation.

Furnace draws power from 12V100W power source. Output power of furnace is controlled with Multicomp MCKSL60D20-L sold state relay with PWM control signal from Arduino Mega2560.

2.7 Serial communication

Arduino Mega2560 uses TTL serial communication protocl and data acquisition PC uses RS-232, so there is a TTL-RS232 transceiver between.

3 Software

Program is in two different parts, Arduino firmware and LabVIEW automation software. All software can be found in git repository `https://github.com/MikkoKivekas/PAC-SLI`.

3.1 Arduino firmware

Firmware is Arduino program that is needed for operation. It opens serial communication channel through USB port to PC and LabVIEW. Firmware is part of MakerHub LINX library that is essential part of the software.

MakerHub LINX pre-built Arduino firmware is the base, but it is customed to have different timers on Arduino's PWM outputs.

More about firmware in README-file.

3.2 LabVIEW

LabVIEW programs are called the VI's. LabVIEW is a graphical programming enviroment using blocks and wires.

PAC-SLI automation is built in LabVIEW and MakerHub LINX library is required.

All VI's are included to PAC-SLI.lvproj LabVIEW project containing two main VI's and several subVI's. There is main VI for only testing some features like temperature reading and photogate reading.

The main automation VI is PAC-SLI.vi. It contains everything you need to run PAC-SLI automation. When program starts running, it initializes connection to Arduino Mega2560 and Arduino's peripherial devices. Then we wait for user input for starting the actual automation cycle, before starting user can change parametres of I/O and cycle steps. After start user should not change the parametres, other than detectors in use.

User defines cycle steps with timing before start and program picks operations and excecutes them with timing that user has defined. There is 8 different operations and one of them accepts extra argument.

Operations are:

0. Prints time (this operation is important designwise)
1. Data acquisition on
2. Data acquisition off
3. Furnace power set (this operation has the argument option)
4. Beam gate off
5. Beam gate on
6. Furnace move out
7. Furnace move in
8. Detector status check

Furnace power setting can be done manually by hand or automated using the argument of cycle step. Below cycle input matrix in GUI is switch that switches between them. Manual set is good for cycle long consistent output power, arguments are good when power output needs to change over time.

Temperatures are read after every step and during idle.

Automation can control up to six detectors. Switching on the dertector user presses corresponding green set LED in Detector settings and status can be read from red indicator LEDs. There is also a tickbox that is ticked if user wants a detector to stay on during whole cycle. This continuous detector can be used for example as ratemeter.

When user wishes to stop using the software, stop-button is pressed and system shuts down. Before exiting the program there is end procedure, that makes sure that it is safe to stop.

4 Operation

4.1 Warnings

Do NOT close program by LabVIEW's abort-button, this messes up communication with Arduino and firmware needs to be uploaded again.

You can not press reset or stop buttons when program is not running the cycle. Start the cycle and stop as soon as possible when needed.

4.2 Settings

4.2.1 I/O channels and photogate

Located in Settings-tab.

I/O channel settings are forced to be right regardint to their connections to Arduino Mega2560. If user of developer wishes to change them, they need to remove restrictions from data entry in LabVIEW.

Photogate threshold voltage maximum can be tested is Testing.vi. Usually threshold voltage 0.3 is ok.

Serial Port setting sets I/O port in PC that Arduiono is connected. COM3 is correct usually, but check right COM-port before running the program.

4.2.2 Thermocouple SPI

Located in Settings-tab.

Thermocouple SPI CS channels are force set regardint to their connections to Arduino Mega2560. CS logic level needs to be set "Active Low".

Clock frequency of SPI can be anything below 15000000, 10000000 is preset and is ok. Bit order must be "MSb First", Most Significant bit First. SPI Mode the thermocouple amplifier uses is "Mode 0".

4.2.3 Atuomation cycle

Located in Settings-tab.

First user sets length of the automation cycle in sesonds to "Supercycle time [s]".

Then in "Operation | Time | Argument" matrix user defines wanted operations in right order from up to down in first column. Next user defines timing to second column. Timing works that user gives time in from cycle start where operation should be excecuted.

If we have a 10 second supercycle and we want to do an operation in the middle of it, we time that to 5 seconds putting 5 in the timing cell.

Timing can not exceed super cycle time! If user puts timing that is more than supercycle time, program sends an error and user has to correct timing. If operations are not in right chronological order, program does not function properly. Probably program waits to the timing of next set operation and if after that is operation with smaller (earlier) timing that is excecuted right after last.

ther eis third column for arguments. Only operation 3. Furnace power set uses argument to set power to. Below the matrix in GUI is a switch that switches between argument and manual power set. Manual power set is done on Monitorin-tab.

4.2.4 Detectors

Located in Monitoring-tab.

User defines here whics of total six detectors are used. Pressing green set-LEDs ON they are in use and ticking the tick box next to LED user defines that the detector ticked is always on. Red LEDs are indicators that indicate when detectros are acquiring data.

4.3 Timign cycle steps

4.4 Step-by-step instructions

1. Connect Arduino Mega2560 to PC with USB-cable
2. Open custom Arduino firmware in Arduino-IDE
3. Upload firmware to Arduino

4. Open LabVIEW VI PAC-SLI testing
5. Set settings right (COM port COM3, SPI mode 0, SPI CS channels 7 and 8, Active Low)
6. Run testing program
7. Check that temperatures are read and photogate has signal
8. Stop testing program using stop button
9. Open PAC-SLI VI
10. Check settings
11. Run the program
12. Wait for the name of microcontroller to appear and stand-by LED to turn on
13. Start program
14. Watch and check that everything runs smooth during first cycles
15. If you want to reset for some value changes, press reset-button
16. After resetting and changing values press start to run
17. Press stop-butten, when ready and you want to stop
18. In case of emergency, press stop-button to seize the program. In extreme case abort from LabVIEW header panel. This breaks the firmware in Arduino Mega2560