VF LCR Tests

The purpose of this document is to describe tests that should be performed on VF-LCR boards. The tests will be run on test PLC.

There are two types of tests:

1. Board functionality tests. This set of tests should be run on new boards to make sure all functionality is correct.
2. Regression tests. This set of tests should be performed on one of the boards to make sure that new revision of the firmware does not introduce any new errors.

# Hardware setup

One LCR assembly has 21 Laser Control Ports (DB-25 connectors). Detailed descriptions of inputs/outputs can be found in “VF-LCR Assembly Testing” document.

## Laser Control Port

* 4 digital output pins (one is modulation pin),
* 4 input pins
* 3 contact closures (these pins can be daisy chained to decrease number of channels)
* one analog output pin,
* one analog input pin
* RS232 RX/TX.

So ideally, we need external Data acquisition system with 4 \* 21 + 3 = 87 digital inputs, 4 \* 21 = 84 digital outputs, 21 analog inputs, and 21 analog outputs, and 3 outputs capable of supplying 24 V.

* contact closure between pins 1 and 4
* contact closure between pins 2 and 3
* short between pins 8 and 9
* contact closure between pins 10 and 11
* digital output, pin 17. 12V
* digital output pin 18. 12V
* digital input pin 19. 12V
* digital output pin 21. 12V
* digital input pin 22. 12V
* digital input pin 23. 12V
* digital input pin 24. 12V
* modulation output pin 15. 12V
* analog output pin 12. 0 to 10 V
* analog input pin 13: 0 to 3.3 V (0 to 10 V in the next revision)
* RS232API23: pin 5 RX, pin 6 TX.

Out of 4 digital outputs there are two outputs (laser modulation and laser emission enable) that we want to check at high speed.

We also would like to check analog output at high speed as well. As far as analog input we can consider connect it to analog output and after verifying analog output functionality/accuracy we can use analog output to check analog input.

## Safety Interlock port

24 V needs to be applied between 1 and 2, and 3 and 4. Verify that 5 and 6 are closed, as well as contacts 1 and 4, and 2 and 3 on J1-j21 are closed.

* 24VDC differential input pins 1 and 2.
* 24VDC differential input pins 3 and 4.
* contact closure output between pins 5 and 6.

## Chiller Interface

TBD

# Board Functionality Testing

The table below shows signals on Laser Control connector

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Name | Input/Output | Voltage Levels | State during printing operation | Comments |
| P1, Interlock | Output | N/A | Connected to P4 |  |
| P2, Interlock | Output | N/A | Connected to P3 |  |
| P3, Interlock | Output | N/A | Connected to P2 |  |
| P4, Interlock | Output | N/A | Connected to P1 |  |
| P5, RS232 RX | Input | +- 30V |  | Currently not used |
| P6, RS232 TX | Output | +- 5.7V |  | Currently not used |
| P7, GND |  |  |  |  |
| P8 | Output | 0 to +24V | +24V | On some lasers P8 connected to P9 through, on others P8 (or P9) connected to +24V |
| P9 | Output | 0 to +24V | +24V | See P8 |
| P10, Remote Start | Output | 0 to + 24V | +24V | On some lasers P10 connected to P11 through mosfet, on others P10 connected to +24 through mostet, P11 not used |
| P11, | Output | 0 to +24V | +24V | See P10 |
| P12, Laser Power | Output | 0 to +10V | Variable | Could be connected to P13 for testing |
| P13, Analog input | Input | 0 to +10V |  | Currently 0 to +3.3V |
| P14, GND |  |  |  |  |
| P15, Modulation | Output | 0 to +17V | Variable |  |
| P16, GND |  |  |  |  |
| P17, Guide Enable | Output | 0 to +17V | 0V | On some lasers can be used to turn on red guide laser |
| P18, Emission Enable | Output | 0 to +17V | +17V |  |
| P19, Error/Ready | Input | 0 to +24V | +24V | +17V – Ready, 0V - Error |
| P20, GND |  |  |  |  |
| P21, Laser Reset | Output | 0 to +17V | 0 V |  |
| P22, CTRL\_SYS\_ON | Input | 0 to +24V | +24V |  |
| P23, Main Power On | Input | 0 to +24V | +24V | +24V if P18 is high |
| P24, Emission On | Input | 0 to +24V | +24V | +24 if P18 is high and P12 above ?? V |
| P25, 24V | Output | +24V |  |  |

# Regression Tests

The purpose of these tests is to verify system performance under most stressful conditions and verify system recovery from various errors. These tests should run automatically and write results into log file.

Hardware setup:

1. LCR system under test
2. PLC with appropriate test program
3. PC connected to PLC and LCR system to upload various VF-LCR files, i.e. LUTs and laser control files.
4. NI Data acquisition system connected to LCR and PC/PLC to measure various LCR outputs and possibly provide analog/digital signals to LCR.
5. PLC should have ability to power down/power up LCR system.

Software setup:

1. Program running on PLC
2. Program(s)/script(s) running on PC

The main control program will run on NI system using LabView. Test PLC program needs to be modified so that LabView can trigger LCR system via PLC (i.e. open layer).

List of tests:

1. Power cycle LCR system and verify that LCR system up and running after appropriate time interval. Verify that all LCR output signals have correct values.
2. Transfer all 21 LUT to LCR system and verity that they are correctly loaded into LCR system.
3. Transfer all 21 laser control files and run open/close layer XXX times without errors.
4. Transfer all 21 laser control files with XX% PWM, open layers and verify PWM on the laser modulation outputs.
5. Transfer all 21 laser control files with XX on power level and verify that analog outputs have correct voltages.

# LCR Performance Tests

The purpose of these tests is to verify that LCR system produce electrical signals according to the spec. In particular, we will test accuracy of laser power (P13, analog output of LCR) and modulation (P15, digital output). To conduct these tests LCR system will be connected to National Instrument high speed data acquisition system (DAQ). NI DAQ consists of analog-to-digital converter capable of running at2 MS/sec, and digital card capable of running at 10 MHz (both modules have 32 inputs), and embedded controller (PC) running Windows 10. The NI system needs to be connected to PLC over the Ethernet in order to control LCR system.

Static accuracy of LCR DAC converter can be tested by loading test voltage map into LCR, command, set voltage to a specific value and measure voltage using NI system. In addition, static crosstalk can be measured as well.

Dynamic response of LCR DAC converter can be tested by changing voltage value and measure dynamic response of the DAC. Again, crosstalk can be measured as well.

LCR ADC accuracy will be verified after performing verification on DAC. ADC input will be connected to DAC output. Since DAC accuracy already been verified we can use its output voltage to check ADC accuracy.

Modulation output will be tested by specifying different PWM values and measure actual on/off values using high speed digital input of NI system.

The more comprehensive test will be to load actual laser files, start trajectory, and acquire both analog output from DAC and digital output from modulation, i.e. we will mimic actual use of LCR. All data could be saved into the file(s) and then analyze off-line to verify its correctness.

One way to quickly verify correctness of the signals is to develop tool that would take saved data and generate an image that would represent laser intensity at each pixel.

## Ramp up Test

Pins tested: ADC output on each channel

The purpose of this test is to verify that ADC in each channel works correctly and correct sequence executed in each ADC channel. All channels execute sequence of on/off steps with laser power increasing from 0 to 255. The encoder step in all channels is 10, but the starting point of each channel is different, i.e. it starts at encoder 510 for the first channel, 1010 for the second channel, 1510 for the third channel, and so on. After acquiring analog data program will fit line and verify that fit parameters are correct.

Test details (laser 1):

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Encoder value | Power value | PWM duty cycle | PWM period | Laser ON/OFF |
| 5 | 0 | 128 | 100 | OFF |
| 510 | 1 |  |  | OFF |
| 515 |  |  |  | ON |
| 520 | 1 |  |  | OFF |
| 525 |  |  |  | ON |
| … |  |  |  |  |
| 3060 | 255 |  |  | OFF |
| 3065 |  |  |  | ON |

After acquiring analog data program fit straight line (V = A\*t + B) and check line slope (A) and offset (B) have correct values.

If test failed it will show failed channels.

## Overshoot Test

Pins tested: ADC output on each channel

The purpose of this test is to measure maximum voltage in each channel if laser power setting changes from 0 to 255.

Details (all lasers)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Encoder value | Power value | PWM duty cycle | PWM period | Laser ON/OFF |
| 5 | 0 | 255 | 100 | OFF |
| 105 | 255 |  |  | ON |
| 1105 | 0 |  |  | ON |
| 1205 |  |  |  | OFF |

After acquiring analog data program calculates maximum voltage values in every channel.

If value in any channel is more than 120 mV above 10 V the channel will fail.

The values of overshoot above 10 V will be shown on the screen (in mV).

## ADC Accuracy Test

Pins tested: ADC output on each channel

The purpose of this test is to verify accuracy of each laser power analog channel. The laser power get sets to values varies from 0 to 255 and at each power level the program measures analog value20 times and calculates average value. Then program compares these average values with expected values.

Details (all lasers):

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Encoder value | Power value | PWM duty cycle | PWM period | Laser ON/OFF |
| 5 | 0 | 255 | 100 | OFF |
| 500 | 0 |  |  | OFF |
| 750 |  |  |  | ON |
| 1000 | 1 |  |  | OFF |
| 1250 |  |  |  | ON |
| … |  |  |  |  |
| 128000 | 255 |  |  | OFF |
| 128250 |  |  |  | ON |
| 128500 |  |  |  | OFF |

After acquiring analog data program will calculate average voltage at each power value and compare with expected value. Test pass if the difference is less than 200 mV.

Test shows maximum deviation (negative and positive) for each channel for all voltages levels (in mV).

## PWM Test

Pins tested: PWM output on each channel

The purpose of this test is to verify correctness of laser modulation output.

This test consists of 2 phases:

* In the first phase program verifies that laser modulation output tuns ON at appropriate encoder counts and stays ON for correct time. This test repeated for PWM duty cycle varies from 0 to 255 while PWM period stays at 255.
* In the second phase program verifies that laser modulation output tuns ON at appropriate encoder counts and stays ON for correct time. This test repeated for PWM period varies from ` to 255 while PWM duty cycle stays at 128.

Test failed if time difference between actual transitions on PWM output and expected time is more than 1 usec.

If test failed it shows maximum deviation on each failed channel.

## Crosstalk Test

Pins tested: ADC output on each channel

The purpose of this test is to verify that setting laser power to maximum value on one channel does not produces any voltage spikes on other channels. The laser power gets sets to max value 255 in each channel in different times and laser power output on all channels gets measured and analyzed.

Details

Laser 1:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Encoder value | Power value | PWM duty cycle | PWM period | Laser ON/OFF |
| 5 | 0 |  |  | OFF |
| 15 | 255 | 128 | 255 | ON |
| 2015 | 0 | 128 |  | ON |
|  |  |  |  |  |

Laser 2:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Encoder value | Power value | PWM duty cycle | PWM period | Laser ON/OFF |
| 5 | 0 |  |  | OFF |
| 15 | 0 | 128 | 255 | ON |
| 2015 | 255 | 128 | 255 | ON |
| 2015 | 0 | 128 |  | ON |

After acquiring analog data the program check voltage on each channel excluding areas where power was set to 255. Test fails if voltage in any channel is more than 120 mV.

Test always shows min and max voltage on each channel (in mV). We may change this behavior after collecting data from many units.

## Digital Pins Test

Pins tested: Digital pins on Laser control connector

This test runs vflcr\_test\_script\_interpreter.py script.