3 – Dimensional Microscopy

Spatial Frequency modulation for Imaging (SPIFI)

Test Plan

Team members

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1. Test Plan Identifier

Our testing plan is to incorporate individual milestones for testing a realistic timeline to insure proper results dealing with two stages, software development and digital image processing. Of course with testing there is always the possibility of error and because of this an excess amount of time has been added to the project timeline tasks. This allows us to have more time than needed in order to meet goals and optimize our project. With this test plan we plan to keep it up to date with biweekly revisions. These will be denoted in revision history.

2. References


3. Introduction

The purpose of this test plan is to insure timelines that can be met in a practical fashion to ensure stability and optimization of the project. Where the project is enhancing SPatial Frequency modulation for Imaging (SPIFI). Here we will set forth a test plan to test items, define software risk issues, define features to be and not to be tested, our approach, items that fail and pass as we progress in the project, resumption requirements, our test deliverables, future or remaining tasking, the environmental needs of the project, individual responsibilities, out timeline and schedule with updates, planning risks and contingencies, and approvals we receive from our project supervisor, Dr. Randy Bartels.

4. Test Items and Functions

Our current project will set out to function as a single-element detector imaging system that uses SPIFI to reconstruct 3-D images from spatially modulated frequencies. With this project we will be incorporating the following items as of 11/01/13.

Specs

De0-Nano

-Cyclone IV EP4CE22F17C6N FPGA

- 3 axis accelerometer with 13-bit resolution
- A/D converter, 8 channels, 12bit resolution
- Memory – 32 MB SDRAM, 2Kb EEPROM
- 50 MHz Clock

**Adafruit 32x32 RGB LED Matrix**

- 5V regulated input, 2A max
- 3-5V data logic level input
- 2000 mcd LEDs on 4mm pitch

**PM10 Photodiode**

- wavelength range .19 µm to 11 µm
- active area diameter 19mm
- max power 30W
- Calibration Wavelength 514
- response time 2 seconds
- broadband detector coating

**Fresnel lenses**

- Focal Lengths ranging from 400-1100nm
- various focal lengths 10mm, 25mm, 32mm, 51mm (subject to change)

**Condenser Lens**

- Diameter 30mm-45mm (subject to change)
- Clear aperture(mm) >90%
- focal length – .08 (subject to change)
With the following specifications a description for functionality of each item will be given. The De0-nano FPGA will be the underlying foundation of our project. This device will directly control the LED functionality and ultimately, create the LED matrix to behave as would a spinning modulated disk would. The FPGA will be programmed to control the brightness, manage frequencies across the matrix, and possibly compute processes of optimizing output signals from input signals for image resolution of the sample being imaged. The Board will be programmed to have the maximum or -%10 of maximum clock speed, that being 50 MHz. The functionality of this FPGA will be tested insure optimum imaging. The adafruit LED matrix will be tested to maintain its durability of dealing with high frequencies running through it. Although we will be in a test environment that will be controlled, we would like to test the functionality of the LED board and its output behavior from the FPGA with varying temperatures. These temperatures would range from -4 to 37 degrees Celsius. This will allow for an understanding of what type of conditions the device can withstand, and what applications it could be applied to. These temperatures will also be tested with the FPGA and photodiode. The PM10 Photodiode will be tested in various conditions and altered respectively for ambient light sources and how those sources affect the resolution of the image. The Fresnel and condenser lenses will be tested for their chromatic aberrations and will be chosen in respects to this and focal lengths.

5. Test Items functionality and functions not to be tested

With the following items to be tested, being the de0-nano, the 32x32 RGB LED matrix, the PM10 photodiode, the Fresnel lenses, and condenser lens there will be certain features that will be stressed during testing and certain features that will be available and could be tested but will not be tested in this phase of the project. Based on results of the current project these items may or may not be tested in the future, but are listed for future reference. The De0-nano being an FPGA has various uses, besides clock speed and its ability to control the board such as wireless control, has tap sensing, and double tap sensing which will not be tested. As for the LED matrix, only oscillations of frequencies will be tested, various items that will not be tested are creating images, or interlacing with other matrices to create a larger array. The photodiode will be tested for digital image processing, all functions of this device will be used. The Fresnel lens will be used to create aberration and will not be used for non imaging techniques such as illumination or projection. The condenser will fulfill its full functionality by condensing the beams.

6. Software Risk Issues

Our current project focuses on using an FPGA which has high processing speeds. With having the core of our project dependent on the functionality of the FPGA we must minimize risks and identify possible risks that are
possible. Here we are faced with the possible risk of development time of developing code due to bugs or using other systems, such as transferring to an earlier version of altera quartis II. Other risks include improper knowledge of relaying the information for quality of resolution to the FPGA to control the LED Matrix, communication in the team, and changing requirements for what is acceptable for resolution quality. Also noise in the photodiode may be a risk and have to be compensated for.

6. Features to be tested

Features that will be tested include the capability of the boards processing speed, brightness vs resolution of the LED matrix, and combining the many frequencies via mathematica to perform the FFT. For the boards processing speed we will be faced with multiple variables such as temperature, communication from the computer, and communication to the LED Matrix. The LED matrix will be faced with alignment, mounting, and position in respects to the sample all in while comparing the brightness vs resolution of the LED matrix for the produced image. The computational system we will use will be subject to dealing with a polychromatic light source vs monochromatic, leaving test room available for altering and defining new functions to process the spatial information received.

7. Features not to Tested

Features that will not be tested include tap capability of the board and remote server capability of the board, interlacing multiple boards to create a larger array of frequencies, angled projections of the board to image, and far field limits of the board.

8. Approach

The approach that will be taken by the team includes two different routes of programming the LED board. We will approach from two sides, the first being pure Verilog programming of the board to control the RGB LED matrix, the second to program the board with a JTAG server to a port in which the port will communicate with processing as the language of choice to control the board. These will be tested for speed vs accuracy and from results one will be chosen and altered to optimize this ratio. We will begin the testing sequence with individual column frequencies in order to see how the current set up behaves and receives the information, this will allow us to see what frequencies are acceptable for the individual LED frequencies. Once we have documented the frequencies and distances that seem to behave the best imaging resolution and speed, we will transfer the board to have individual LED frequencies and adjust position of frequencies on the board with respects to distance to optimize resolution and processing speed. This will be done in 2-D. Once the 2-D factors have been
weighed in and optimized we will then collaborate with the Colorado School of Mines team to map our third dimension. The process of testing LED frequencies will be repeated for the distance and processing speed vs resolution. Specific training will be instructed by the Bartels’ Lab to insure accurate results. Regression steps will be taken accordingly based on results.

9. Item Pass/Fail Criteria

The item pass/Fail will updated once the testing phase is in progress. This will be updated in the revision section.

10. Suspension Criteria and Resumption Requirements

If the programming vs testing reaches a point where results are not efficient by December 2013, the project will be killed. We are looking to have respectable results that show progress rather than continuation with no results. If damage to the lab or moving of the lab delays this process a new time constraint will be implemented. Some possible defects that could effect this result are water damage to electronic equipment, system failure and loss of files, or faulty team communication to meet deadlines.

11. Test Deliverables

<table>
<thead>
<tr>
<th>Task Name</th>
<th>Duration</th>
<th>Start</th>
<th>Finish</th>
<th>Predecessors</th>
<th>Status</th>
<th>Milestone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Set up of altera quartus II</td>
<td>5 days</td>
<td>Mon 9/23/13</td>
<td>Fri 9/27/13</td>
<td>0</td>
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<tr>
<td>Wiring of De0-nano</td>
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<td>Fri 10/4/13</td>
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<tr>
<td>Delivery of LED Boards to Colorado School of Mines</td>
<td>1 day</td>
<td>Fri 10/4/13</td>
<td>Fri 10/4/13</td>
<td></td>
<td>Complete</td>
<td>No</td>
</tr>
<tr>
<td>Programming the de0-nano to represent single columns of light of the LED each of different frequency</td>
<td>12 days</td>
<td>Fri 10/4/13</td>
<td>Sun 10/20/13</td>
<td>2</td>
<td>Complete</td>
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<tr>
<td>Testing effectiveness of LED frequency with SPIFI individual columns</td>
<td>4 days</td>
<td>Wed 10/16/13</td>
<td>Sun 10/20/13</td>
<td>4</td>
<td>Delayed</td>
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</tr>
<tr>
<td>Fine tuning of most effective frequencies with spifi</td>
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<td>Sun 10/20/13</td>
<td>4</td>
<td>Delayed</td>
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<tr>
<td>Task Description</td>
<td>Days</td>
<td>Start Date</td>
<td>End Date</td>
<td>Count</td>
<td>Status</td>
<td>Notes</td>
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<tr>
<td>Programming the de0-nano to represent full array of frequencies (1024 different frequencies)</td>
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<td>Thu 11/21/13</td>
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<td>Complete</td>
<td>No</td>
</tr>
<tr>
<td>Testing effectiveness of LED frequency with SPIFI with 1024 different frequencies</td>
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<td>Tue 11/19/13</td>
<td>Wed 12/4/13</td>
<td>10</td>
<td>In progress</td>
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<tr>
<td>Data collection from columns</td>
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<td>Sun 10/20/13</td>
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<td>In progress</td>
<td>No</td>
</tr>
<tr>
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<td>Wed 12/4/13</td>
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</tr>
<tr>
<td>Results and project development paper</td>
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<td>Fri 12/13/13</td>
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<td>In progress</td>
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</tr>
<tr>
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<td>In progress</td>
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<tr>
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<tr>
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<td>Mon 12/2/13</td>
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<td>In progress</td>
<td>No</td>
</tr>
<tr>
<td>Mapping of 3-D imaging with Colorado School of Mines</td>
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<td>Tue 1/21/14</td>
<td>Wed 4/16/14</td>
<td></td>
<td>In progress</td>
<td>No</td>
</tr>
<tr>
<td>Demonstration to middle-school to instill the possibility of technology and spark interest in a technology based major</td>
<td>1</td>
<td>Spring</td>
<td>Spring</td>
<td></td>
<td>In progress</td>
<td>No</td>
</tr>
</tbody>
</table>
Addition to test deliverables based off of test developments | 1 day | Tue 1/21/14 | Tue 1/21/14 | In progress | No

12. Remaining Test Tasks

As of 11/01/13 remaining test tasks include testing of 2-Dimensional digital image processing using the programmed De0-nano. We have delayed the process of testing individual column frequencies to be tested in the same span of as that of individual LED frequencies. This will insure a more practical timeline for deliverables. After the mapping of 2-D, we plan to repeat the process but by adding the third spatial coordinate into our imaging system to compute. This is expected to be done by rotating the sample and capturing tomographic slices and then recombining these slices to produce a 3 dimensional image.

13. Environmental Needs

Since we are currently in a world with various environmental impacts that are easily effected we have made a list of possible environment impacts of project, those being natural environmental and industrial environmental impacts. Since we are dealing directly with electronics, the disposal of these devices if they are to malfunction or break will be recycled as electronic and computer waste. Since we will be putting of no emissions of any sort, this will be our only natural environmental concern. For industrial we are focused on only the wireless JTAG server and will respect the local wireless community by running our port through a well defined server. Since our power consumption is minimal and we will not be in any sort of manufacturing stage during our timeline, we have denoted all industrial environmental needs.

14. Staffing and Training Needs

Since the senior design team is new to the Bartels’ lab and have been accepted into the lab to use test equipment we are grateful to receive basic lab procedures and training that will be granted. Currently we are subject to training on handling specific optical equipment and how to process and what to look for when imaging. We will be trained in basic digital image processing and reconstruction using SPIFI. We will also be subject to safety procedures such as protective eyewear and handling sensitive equipment.
15. Responsibilities

The responsibilities of the project will be handled the same, except for the beginning task of performing two different methods of programming the FPGA board to control the LED matrix. Currently the team leader title is handed to Nicholas Galvan who is subject to Dr. Randy Bartels. Tyler Green, the other team member will be held responsible for meeting timeline deliverables, as well as setting risks, selecting features to be tested and not to be tested. Nick will be in charge of making critical decisions for testing, the overall test plan strategy, as well as setting defining risks. Together the team will receive training from Jeff Fields and Dr. Randy Bartels for use of the lab equipment, and then will be subject to define their own test results.

16. Schedule

Our schedule although defined to grant us excess time, still is subject to pushback dates due to risks and unforeseen issues. Since we have set a timeline of deliverables we plan to push them as much as possible and will allow for a two week pushback for milestones. Also milestones may be subject to switch dates based on decisions of the team leader and Dr. Randy Bartels to insure proper time management and assessment of testing. Since we will not be pushing towards the manufacturing side of this project we will not be focusing on consumer needs, however; we will be focusing on patenting the idea. This will be discussed in further detail based on test results in December.

17. Planning risks and Contingencies

Since there are hundreds of variables to be considered with testing, basic risks of products have been set forth as in our risk analysis. Some variables that will be stressed again and for the first time include lack of personal resources, delays in training, changes to design and pushback dates on milestones, number of tests that will be performed that insure low error, overtime work hours, late delivery of material, and additional team members added. For lack of personal resources we are subject to the rules and hours of the Bartels’ lab, although access should be granted on a fairly lenient basis, current testing of experiments may delay testing of our project. Delays in training may also be caused by this factor of current testing and schedules of the Bartels’ lab staff. As for changes in deliverables, the risk include pushing or altering team member schedules which then cannot adhere to the new schedule. As for number of tests, we may have to perform many more tests than to be expected in order to insure accurate and consistent results. In order to make deadlines in an acceptable fashion overtime may be required of team members, this risk includes breaking down team member mentality. Late
delivery of material may push back results substantially due to various schedules of training staff and future schedule of team members. Additional team members provide the risk of more time added to training and catching those team members up to speed if needed, although our group is solidified, the Colorado School of Mines team may have additional team members then previously denoted.

18. Approvals

Dr. Randy Bartels for testing and test plan