**Memo**

**Senior Design**

ENG EC 463 / 464

To: Professor Pisano

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Date: 2/16/17

Subject: Second Deliverable Testing

1. **APD Measurements - Frequency Modulation Sweep Testing**
   1. **Description & Goal:**

Our DOSI probe differs from existing probes with its use of miniaturized components as well as the ability to output four different wavelengths of light through a single source. The source in our optode is a newly designed and manufactured four-wavelength VCSEL and the detector is a miniature Avalanche Photodiode (APD). With the VCSEL PCB already in place, our current goals are to create a working APD PCB that can interface and mate with the VCSEL board to take full measurements of breast tissue during a chemotherapy treatment. To do this, we make a schematic of the PCB, design the PCB itself in software while taking into account principles of PCB design, and send out our design for printing. Once we get the board, we cut it to shape and solder components into it. The final step involves testing the board by verifying that we can pick up signals with a high signal-to-noise ratio through the APD. We also want to assure that the board can be kept flush with the surface of our phantom and that it has all the switching capabilities of the previous evaluation board from Hamamatsu.

* 1. **Procedure:** 
     1. PCB Design

To design a PCB, one first needs a circuit diagram to base it off of. In order to make the APD PCB, we obtained some old schematics of APD PCBs from the Electronics Design Facility and analyzed them. The current APD PCB in use in Professor Roblyer’s lab was used as a base for our design.

The PCB design software ExpressPCB was used to design the board. Factors such as simplicity, ease of use, depth of the individual parts (to keep the APD flush with the surface), soldering ability, and size were considered in the design process. In addition, we tried to take into account the characteristic impedance of the traces themselves, and thus made the traces for the high voltage connection and the RF outputs much larger. Once the board arrived, we soldered the parts on by hand, with the exception of the APD itself. For the APD, we had the EDF solder it on for us, due to its incredibly small contact points.

* + 1. PCB Testing

Place the VCSEL into the VCSEL PCB and make sure that the ground pin on the VCSEL lines up with the top pin on the VCSEL PCB. Connect the current controller to the biased T and then connect the biased T to both the VCSEL PCB and the RF switch. Make all of these connections using RF connectors. The VCSEL will need UMCX adapters. Make the above connections for all 4 wavelengths. Supply 5 V DC to the RF switch. Connect the voltage source to the low voltage input of the APD PCB and set it to 3.3 V DC. The high voltage inputs should be connected to a high voltage power supply set to 200 V DC. Make sure the APD PCB switches are in the correct configuration. For the first test, they should be in Low Gain, DCFB off. These switch settings correspond with the table below. Make sure all of the USB connections are in place and the computer is running in 32-bit mode for LabView control of components. Make sure that output 1 for the APD board is connected to Port 2 on the network analyzer using an RF connector. Turn on the network analyzer, the current control, the DC power supplies, and the high voltage supply.

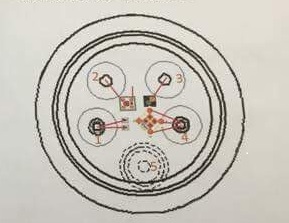
For the network analyzer, change measurement to S21 and autoscale the graph. The start and stop frequencies are set to 50 MHz and 500 MHz with a 6 dBm power limit. On the current supply, the current for the lasers should be as written in the table above (can be changed in “Change Settings”). The lasers that are connected should be turned on. In this case lasers 1 through 4 should be turned on.

On the computer, open the DOS System -> Benchtop DOS System -> Senior Design to open the LabView system. Enable saving, and input a file name and ID. Hold the VCSEL so it outputs into the Acrin 009 phantom (This phantom is used because it simulates breast tissue). Place the APD flush onto the surface of the phantom near the VCSEL and measure the source detector separation. Input this separation into the LabView program. Make sure that both the VCSEL and APD are near the center of the phantom because near the edges the light scatters in a different way which is not ideal for testing. Click “Change Settings” and set the appropriate currents for each laser. Make sure to take note of which laser is connected to which wavelength of the VCSEL since each wavelength takes a different current and we don’t want to blow out the VCSEL. The VCSEL current table is shown below. Finally, hit the “Take Measurements” button to start the measurements. Repeat this measurement for the next test setting with the switches set to Low Gain and Background Correction (DCFB) on. Also, take noise-floor measurements for each of the two settings. This is done by placing the VCSEL and fiber flush onto a piece of rubber which allows no light scattering. For the high gain setting use a balun and connect both output ports on the APD PCB to the inputs of the balun and connect the output of the balun to the Network Analyzer.

* + 1. APD Switch Setting Table

|  |  |  |
| --- | --- | --- |
|  | Position 1 | Position 2 |
| Switch 1 | High Gain | Low Gain |
| Switch 2 | DCFBon | DCFBoff |

* + 1. VCSEL Current Setting Table



|  |  |  |  |
| --- | --- | --- | --- |
| Pin Number | Connection | Max Current | Used Current |
| 1 | 660 nm | 16 mA | 10 mA |
| 2 | 680 nm | 30 mA | 15 mA |
| 3 | 775 nm | 12 mA | 5 mA |
| 4 | 795 nm | 50 mA | 10 mA |
| 5 | Ground | N/A | N/A |

* 1. **Verifiable Result:**

Our test results should have better signal-to-noise ratios than the test results from previous tests with the Hamamastu evaluation board. This is because we will no longer be introducing the noise from an optical fiber, which had been necessary to use with the old board.

The switching capabilities of the new board will be verified by comparing to previous data. The low gain setting with background correction on should have the highest signal-to-noise ratio, while the high gain setting with background correction off should have the lowest.

1. **Tag Generation from Data Files**
   1. **Description & Goal:**

A crucial component of the database that will be used to store patient data is the tags associated with database uploads. Tags are what will organize data by such categories as patent name, date of recording, equipment used, etc. Each data recording session creates multiple files composed data and metadata. For autonomous database uploads, a script is needed to parse through these files, generating relevant tags from the metadata. Metadata is always stored in a distinct number of known locations in the file, so with a predefined file structure, generating tags is a matter of parsing through text.

* 1. **Procedure:**
     1. Detect File Structure

Depending on the DOSI system used, data output has different file structures. The vast majority have their metadata as a header in the first several lines of the file, with a descriptive filename that designates the order which the data was recorded. A minority of files from DOSI systems used in clinical trials have metadata in both headers and footers, with a descriptive filename that designates the date of data collection. Presently, all files generated from our probe contain all their data in the file’s header.

* + 1. Extract Metadata

The text within the file formats is predictable and consistent, so the start and end of contained metadata is simple to detect. The lines that compose metadata are written into a vector of strings to be parsed through later.

* + 1. Organize as Tags

Lines of metadata are typically of the format “title: value”. The script looks for this format in each line of metadata. Titles and values are separated by looking for “: ”, i.e. a space and a colon. These values are written to two vectors of strings, one vector for tags and the other for values for each title.

* 1. **Verifiable Result:**

The script, upon running with the input of a data file, should print out correct tags, verifiable by comparing with the file’s known tags, further verifiable by repeating this process for a multitude of files of different file structures.