

## LAB NOTEBOOK #1 Name

Lab phone: (505)277-8480

Office phone

May 2016: This is the first electronic notebook for state discrimination  
by Name

05-02-2016

Aligning the 633nm HeNe laser on the big table

Transmission through Optical Isolator: .9200

- 1.650 mW → 1.518 mW

Transmission through AOM in 1<sup>st</sup> order mode: .7819

- 1.550 mW → 1.212 mW
- Power was measured right before AOM and right after the aperture (Transmission includes power loss from HWP, PBS and lens)

05-03-2016

Getting .705 in 1<sup>st</sup> order mode, realigning the AOM

05-05-2016

Transmission through Optical isolator: .9301

1.652 → 1.534

Transmission through JUST the AOM without ON: .9981

1.508 → 1.505

Transmission through AOM and elements in 1<sup>st</sup> order mode: .8206

1.505 → 1.235

Total Transmission in 1<sup>st</sup> order mode: .7476

1.652 → 1.235

05-09-2016

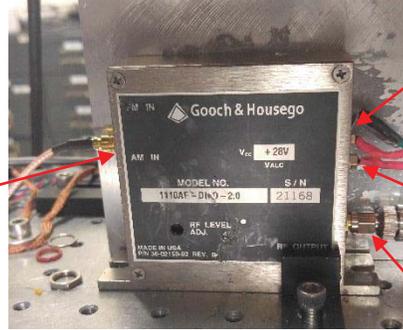
Measuring 633nm laser coupling through different elements

Transmission through isolator: 1.636 → 1.568(no reduction) T: .9584

Transmission through isolator reversed 1.636 mW → .425 uW **Isolation:  $2.60 \times 10^{-4}$**

Transmission through isolator: 1.636 → 1.557(with reduction) T: .9529

## Acoustic Optical Modulator



This is the Amplitude modulation input. It is where the input power goes into the driver. The signal is being sent by the FPGA (Pulsed) or by one of the power supplies (Continuous) below the table. It is the main voltage and signal input. This is a digital input

This is the  $V_{CC}$ , it is the supply voltage that the ALC uses in order to stabilize the intensity. It comes from a power supply below the table. This is a digital input.

This is the  $V_{ALC}$ , it is the voltage that is supplying the ALC. The ALC is used to control the RF intensity. The driver gets this voltage from the PID. This is an analog input

This is the RF output that is the signal that goes to the AOM. This is an analog output

DIGITAL VS. ANALOG:  $V_{CC}$  vs.  $V_{ALC}$

Digital is for the on off changes which is what  $V_{CC}$  is for

Analog is for the continuous changes which is what  $V_{ALC}$  (from PID) is for

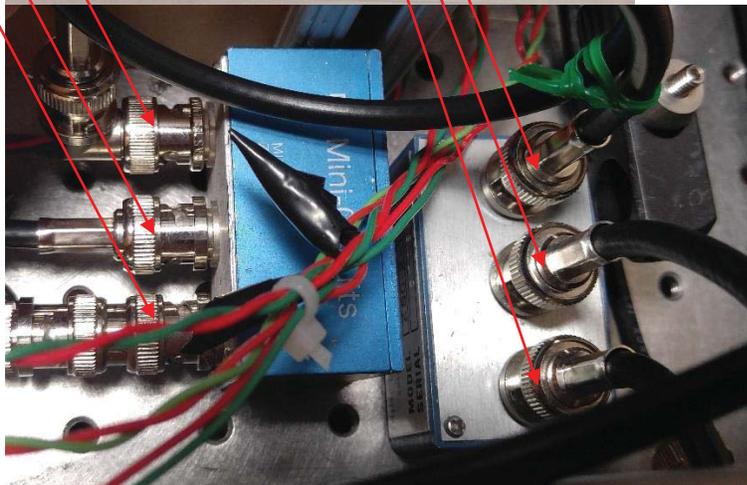
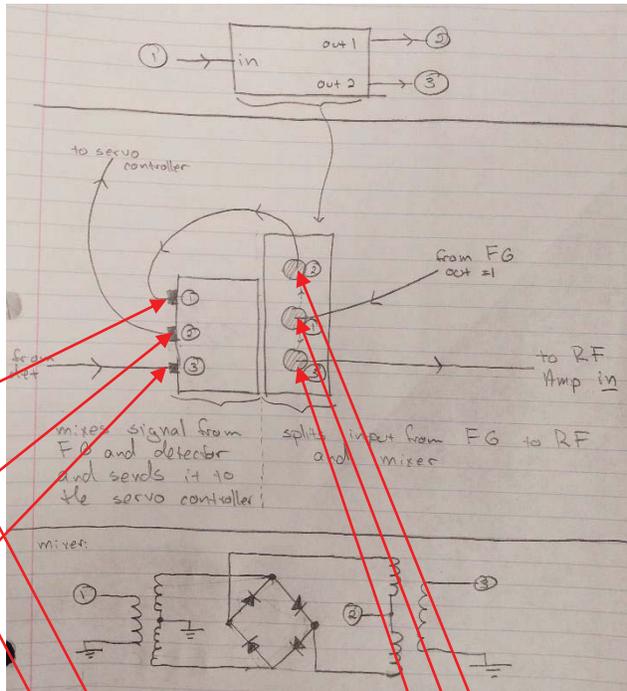
05-13-2016

Aligned the fiber a little bit (~60% Transmission). Need to adjust the last two mirrors and the stage to optimize. The axis along the fiber should be done incrementally instead of continuously (35mm to start then optimize, then change to 45mm and optimize, if 45mm optimized value is less than 35mm value, go back to 35mm for example). Conversion on the volt meter is approximately: **1.75 V/mW**. Good coupling efficiency would be in between **75-80%** so the corresponding voltage is about **1.55V**

June 2016

06-07-2016

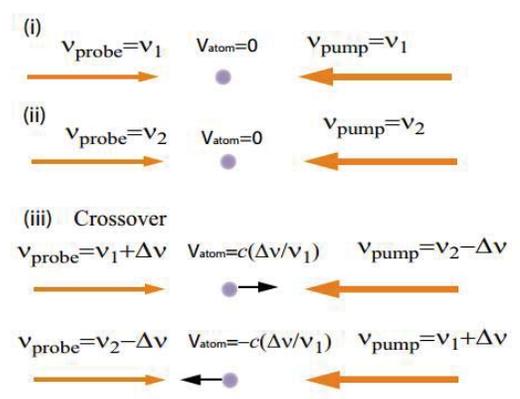
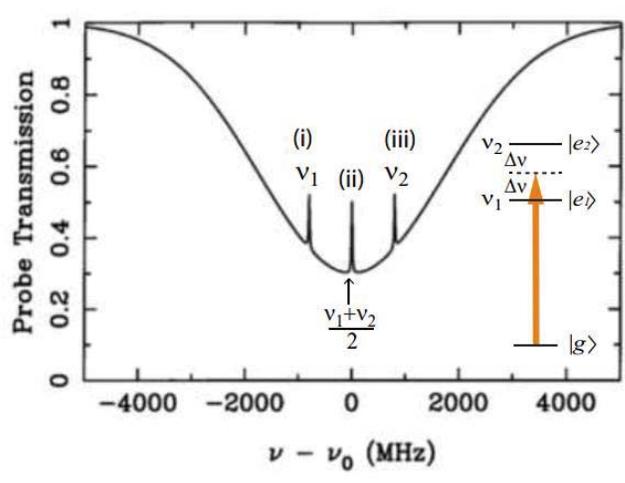
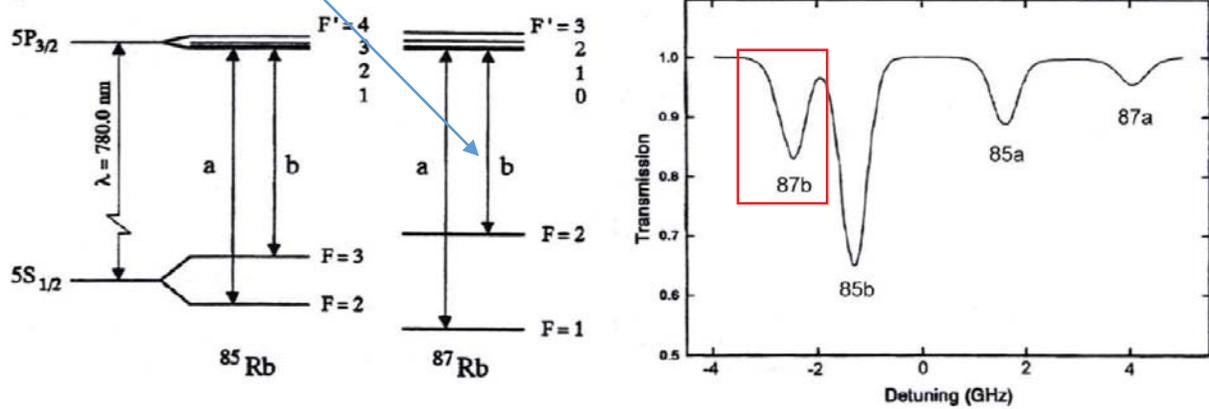
Learning the 780-locking laser:

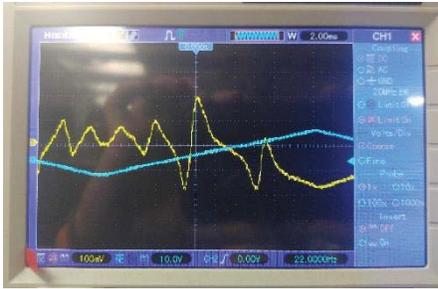


The sweep signal is generated with the function generator. Two outputs are generated. The first output is split with the splitter on the right in the picture. One half goes to an amplifier then TANK circuit then to the EOM. The other half goes into one input of the mixer which is on the left in the picture. The other input for the mixer is the signal from the detector. These two signals are mixed and then amplified, put through a low pass filter, and then amplified again. The combined, amplified signal is then fed into the -B port of the servo controller. The second output of the function generator is fed into

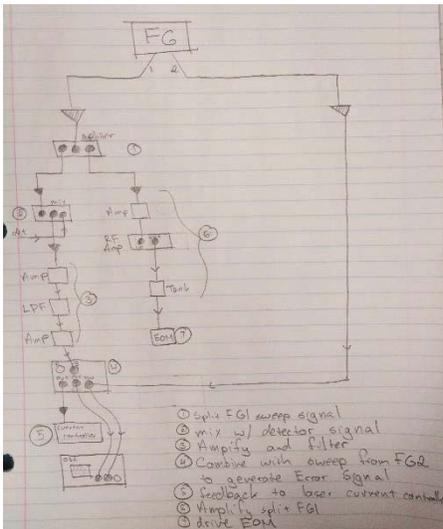
the “Sweep In” input on the servo controller and the output error signal is sent to the oscilloscope along with the sweep signal from the function generator. The output is then fed into the current controller in order to stabilize the frequency of the diode laser. Stabilizing the frequency will translate into stabilizing the phase difference in the interferometer in the big box.

**Sweep signal:** The sweep signal is a sweep wave generated by the function generator that sweeps the frequency. We need a sweep in order to sweep in frequency space through one of the hyperfine Rb transitions and get the “best” error signal we can get in order to stabilize the frequency. The sweep length is fixed but can be shifted by increasing or decreasing the current on the laser manually with the knob. Increasing the current will decrease the frequency and decreasing the current will increase the frequency. We need to use the oscilloscope to set the current for the laser to match the “cross-over” resonance of the 87b transition:





Error signal on the oscilloscope for sweeping through the 87b transition. Use the span, signal, and center offset knobs on the servo controller to line up the steepest slope in the middle. Then flip the switch to lock the interferometer.



Outline of the electronics. The sweep signal starts from the function generator then is split, mixed with the signal from the detector, amplified and combined with the same sweep signal to generate the error signal which then controls the current controller for the laser. The other part of the sweep signal is sent to the EOM to actually scan the frequency near the cross-over resonances

06-08-2016

From the HeNe fiber, the light goes through:

1. Polarizer
2. Wedge
3. Lens
4. (Attenuator and PBS)x4
5. Diachroic filter (for 633nm)
6. 50/50 beam splitter
  - a. **LO**
  - b.  $\frac{1}{2}$  waveplate
  - c.  $\frac{1}{4}$  waveplate
  - d. Coupler
7. 50/50 beam splitter
  - e. **SIGNAL**
  - f.  $\frac{1}{2}$  waveplate
  - g.  $\frac{1}{4}$  waveplate
  - h. Attenuator
  - i. Coupler

NOTE: 1.61V on the multimeter = .820 mW out of the fiber → **.5093 mW/V**

06-13-2016

Managed to get 1.835 volts on the voltmeter: Corresponds to fiber coupling of .7598, gives .4013 mW at detector and .9346 mW at the end of the fiber.

Looked at starting to correct for the phase that the AM gives the LO. Interference pattern is fast oscillation and a slow oscillation. The fast corresponds to the AM being driven by a sweep that is sweeping through a power range. Since the AM is essentially a MZ interferometer, these are the fringes seen from that. The slow oscillations are the fringes that are due to the AM giving the LO a phase shift.

**In Elohim's notebook: 2/03/2016 and the next few days have info on correcting for the phase shift in the past. Also around 8/01/2015.**

Started looking at maximizing the visibility is the fringes in the interferometer. There are two sets of three and two sets of two dials that control half and quarter wave plates which I use to maximize visibility. **QWP: jumps circular polarization up to the equator, HWP essentially rotates linear polarization in the equator by "flipping" is about the axis set by the dial.**

To maximize visibility use the set of dials for the signal right before it goes into the displacement beam splitter. The configuration is from left to right: **Q-H-Q**. Adjust the HWP first. On the servo controller, adjust the Center Offset so then we are looking at the minima in the oscilloscope. Turn BOTH signal and LO off so that we can know where the background is and adjust the up/down so that it is near the bottom line. Then turn both back on and adjust the HWP and first QWP to bring the bottom of the fringe as close to the background as possible. Use the center offset to keep a fringe in the middle of the scope.

NOTE: bottom of fringe:  $V_{\min}$  top of fringe:  $V_{\max}$  background:  $B$

Then the visibility:  $(V_{\max} - (V_{\min} - B)) / (V_{\max} + (V_{\min} - B))$

06-14-2016

Best settings for fiber coupling (Top : Side : Focus) 15:5:37

To maximize transmittance of the Signal, adjust B-M11/B-M12 (Interferometer Box, mirror 11/12)

To maximize transmittance of the LO, adjust B-M13/B-M14

**To measure High/Low- $V_{\pi}$  and change from fast axis to slow axis for the S(LO) PM**

1. LO and Sig are ON and have the same power
2. Function generator is outputting to the Signal(LO) PM
3. Adjust D7(D9) & D8(D10) until changing the offset on the servo controller only shifts the fringes side to side, not up and down. This is aligning to one of the two axis.
4. Line up a point (middle of fringe) with the zero crossing of the oscilloscope
5. Change the offset on the function generator until the middle of the fringe has shifted by over by  $N*\pi$
6. The offset divided by  $N$  is the  $V_{\pi}$

7. Now adjust D7(D9) & D8(D10) until the interference is gone (line is as flat as possible). This means the LO and Sig are in opposite polarizations and not interfering.
8. Then adjust D5(D2) until the fringes are only shifted by the offset, and not raised or lowered
9. With the same offset voltage, the slow axis corresponds to more fringes because the light is spending more time in the PM.

#### To align the polarizations of the S(LO) PM's:

1. LO and Signal are ON
2. Function generator is outputting to the Signal(LO) PM
3. Set the PP at around 4V with no offset
4. Adjust the oscilloscope so that you can see the bottom of three fringes
5. Zoom in to 5mV/
6. Adjust D7(D9) & D8(D10) to make the bottom of all three fringes even
7. Change the PP to around .2V
8. Zoom in to the bottom of the middle fringe
9. Use D4(D1), D5(D2), & D6(D3) to maximize visibility
10. Repeat steps 3-9

#### To align the AM:

1. Just the LO is on
2. Function generator is outputting to the LO AM
3. Set the PP at around 4V with no offset
4. Adjust the oscilloscope so that you can see the bottom of three fringes
5. Zoom in to 5mV/
6. Adjust D9 & D10 to make the bottom of all three fringes even
7. Change the PP to around .2V
8. Zoom in to the bottom of the middle fringe
9. Use D1, D2, & D3 to maximize visibility
10. Repeat steps 3-9

06-15-2016

#### Electronics Settings:

633 Laser

1. Detector -> Voltage Divider -> Amplifier -> PID -> Box? -> RF Driver -> AOM
2. Amplifier: **Coupling** = DC, **Invert** = Off, **Low Pass** = 12, **Source** = A, **Filter Cutoff** = 300 Hz, **Gain Mode** = Low Noise, **Gain** = 1
3. PID: **Offset**: .121

Differential Det.

1. Differential Detector -> Amplifier -> Oscilloscope
2. Amplifier: **Coupling** = DC, **Invert** = On, **Low Pass** = 6, **Source** = A, **Filter Cutoff** = 3 kHz, **Gain Mode** = Low Noise, **Gain** =  $2 \times 10^2$

## 780 Laser

1. Detector -> Amplifiers -> Mixer(3, In)
2. Function Generator Channel 1 -> Splitter(1, In)
3. Function Generator Channel 2 -> Servo Controller Sweep Signal -> Oscilloscope Input 2
4. Servo Controller Error Signal -> Oscilloscope Input 1
5. Splitter(2, Out) -> Mixer(1, in)
6. Mixer(2, out) -> Amplifier -> Low Pass Filter -> Amplifier -> Servo Controller -B
7. Servo Controller Out -> Current Controller
8. Splitter(3, Out) -> Amplifier -> RF Amp -> Tank Circuit -> EOM
9. Function Generator Channel 2: **Function** = Sin, **PP** = 500 mV, **Frequency** = 16.430 MHz, **Offset** = 0
10. Function Generator Channel 2: **Function** = Sweep, **PP** = 1 V, **Frequency** = 23 Hz, **Offset** = 0
11. Temperature Controller:  $I_{LIM} = 1.151$  A,  $T_{SET} = 14.13$  C, **Sensor** = AD590
12. Laser: **Mode** = Constant I,  $I_{LIM} = 129.4$  mA

## PM/AM Box

1. Inputs: Temperature Controller, Function Generator, MUX
2. Temperature Controller:  $I_{LIM} = 1.004$  A,  $T_{SET} = 40.01$  C, **Sensor** = AD590

06-16-2016

Modulator	High $V_{\pi}$	Low $V_{\pi}$
Signal PM	1.910	.734
LO PM	1.967	.737
LO AM	1.020	.352

Make Signal and LO intensities match before everything. This usually causes stuff to not look good and is simple to check.

# TAKE DATA PROCEDURE

## Check powers

1. Maximize coupling power 633nm laser into the large interferometer box with detector and volt meter
2. Check power of the LO: coupling into fiber. Align LO and check it with the Newport power meter
3. Check coupling of the signal the same way.
4. Check coupling of the 780nm into the box (from the 780nm laser box). Look at it with the power meter with setting at 780nm. (if you are in the setting for 633nm then it should be about 116uW.)

### Check Polarizations

Experiment runs in the configuration where all modulators are aligned with the low pi voltage. All polarizations need to be aligned such that visibility is about 99.7-8% (make sure all modulators are adequately terminated or connected)

### Check interference

1. Scan with PZT and optimize visibility with D4, D5, & D6 before 99/1 BS
2. Stop PZT scan, and scan the S-PM with the function generator at  $V_{pp}=4V$  and check that the three interference fringes that you can see have the same low level in the smallest scale: 2mV, this means that they will have the same visibility
3. If not the same, scan at  $V_{pp}=4V$  and adjust D7 & D8 to make the levels even. This will reduce the visibility in the interference.
4. Then go back to D4, D5, & D6 and optimize visibility. For this you should scan with the Function Generator with  $V_{pp}=0.2V$  and with a zero offset.
5. Repeat 2-4 until visibility is maximized and the fringes all have the same low level.
6. At this point the signal should be aligned well. Then next is the LO-PM and the LO-AM.
7. Do the LO-AM first. Block Signal arm and scan LO-AM with  $V_{pp}=0.2V$  and an offset of  $V_{off} = -.3 V$ . Make sure that the three interference fringes all have the same low level and maximize visibility. Keep a low scan amplitude and use Function Generator offset to go to the lower, upper peaks to check visibility.
8. Optimize the polarization of light arriving to the LO-AM with D9 & D10 for the fringe level and D1, D2, & D3 for the visibility
9. Repeat 7, 8 until visibility is maximized and the fringes all have the same low level.
10. Now we have changed the polarization of the interference. Unblock the Signal arm and optimize interference visibility as in steps 2-4.
11. At this point the S-PM and the LO-AM have good polarization alignment. Now we need to check the LO-PM polarization alignment. The problem here is that the polarization of the LO-AM depends on the polarization of the LO-PM, so every time that we change the LO-PM polarization, we need to check the LO-AM polarization.
12. Scan the LO-PM at  $V_{pp}=.2V$  with a zero offset of the function generator and the visibility should be good. Then change the scan to  $V_{pp}=4V$  to check polarization of the LO-PM (the three interference fringes that you can see should have the same low level in the smallest scale: 2mV, which means that they will have the same visibility, Alternatively do a  $V_{pp}=2V$  and use Function Generator offset to go to the lower, upper peaks to check visibility).
13. If not the same, scan at  $V_{pp}=4V$  and adjust D9 & D10 to level up the three peaks. This will reduce the visibility in the interference.
14. Here there are two paths, but not necessarily one working better than the other:
15. If the LO polarization was no moved too much, then: go back to D4, D5, & D6 and optimize visibility. For this you should scan with the Function Generator with  $V_{pp}=0.2V$  and with a zero offset.
16. Repeat until success: order may change (polarizations and powers too!!!)

### Check interferometer CW

1. Lock 780nm frequency.
2. Check 780 nm laser power and check interference fringes:
  - a. Look at fringes from the “780nm differential detector”.
  - b. **Scan with PZT** and observe fringes. If fringes are not good in terms of power, then adjust D11 & D12 on the side of the box
  - c. Good coupling: fringes at **120uW**(Measured with power meter detector) at the input of interferometer gives **40mV PP** interference fringes signal in the oscilloscope (set the oscilloscope at 5mV divisions, fringes should cover 8 divisions peak to peak).
3. Check that the lock works in the CW by locking the interferometer.
4. At this point your polarizations are good and will drift not much and your powers are good.
5. SANITY CHECK: check that the two beams are aligned to the 780 differential detector. This will require some discussion of how to do it.

### Calibrate attenuators

1. The attenuators are calibrated with the **Signal Field only!**
2. The calibration of the attenuators is done with the trap detector.
3. Transimpedance amplifier offset has to be adjusted to diminish noise.
4. **Important: turn off 780nm laser. It produced background in the detector.**
5. Make sure the signal is aligned and adjusted to have the same power of the LO.
6. Run voltmeter program and Trap amplifier program to look at the background in gain setting  $G=10^9$ , blocking the Signal input to the S-PM, and flipping the “power-meter” mirror.
7. Use the excel sheet with the **Mark 1.3 Att’s** tab to calculate the total attenuation
8. Use the excel sheet with the **Calculate Powers** tab to calculate the power needed. Copy the **total attenuation number** (red number at top) from A1A2A3 calibration into the “Calculate Powers” tab in the spreadsheet. Select the rate we want (usually  $1 \times 10^5$  photon/s) this will tell you what voltage you want to see on the trap detector. Change adjust the wheel on the front to change the power to the trap detector. **Once the attenuators are calibrated, you attenuate the one on the front so that there is a certain voltage on the Trap detector in order to see  $1 \times 10^5$  photons/second**

[Voltmeter Program](#) in [W:\Experiment Programs\State Discrimination Programs\DVM](#)

[Trap detector program](#) in [W:\Experiment Programs\State Discrimination Programs\Trap Detector](#)

[Attenuator 1-3 Program](#) in [W:\Experiment Programs\State Discrimination Programs\Rotation Stages](#)

[Excel Sheet --> Mark 1.3 Att’s AND Calculate Power](#) in [W:\Experiment Programs\State Discrimination Programs\Calibration Attenuators](#) .

**Attenuators 1-3 are used as two-position attenuators (on and off).**

**Attenuator 4 is used as continuous attenuator.**

### Check APD alignment

Not much to do, just go to the spreadsheets and check all the numbers for counts based on the number of photons per second we want. And check background/dark counts.

The APD is a Tau-Spad from Picoquant, **APD is about 84% efficient**. In the front of the APD we have a **Semrock filter with about 98.5% transmission** and an **aspheric lens with less than 0.5% absorption**. It is used to focus light into the APD to a very small spot, and is set to get the best detection efficiency. Also the XY state is set to get the best DE. Together **the APD-filter-lens assembly has a detection efficiency of about 82%**.

Once Attenuators A1A2A3 are calibrated with the trap detector, we can calculate the power to prepare  $1 \times 10^5$  counts/second arriving to the APD, and we should expect about 82,000 counts/second.

1. Configure FPGA with W:\FPGA Programs\Elohim\ElohimFPGACyUSBMark1\_3\Mark1FPGABinaryVerilogCyUSB\FILES for Strategies\testingigo\_all.rbf
2. Open LabView APD program: CountsElohim
3. APD unplugged, run LabView program to see no counts but time elapsing
4. **PUT A1, A2, A3, IN**
5. Plug APD in, should see dark counts
6. **Change buttons so that light is hitting APD**
7. should expect about 82,000 counts/second because of the efficiency

The **detection efficiency of the receiver is about 71%**, which takes into account the APD detection efficiency, and the losses from the place where the S field is prepared, right before the 99:1 beam combiner that is used for performing the displacement operation.

### **NOTE in the DE**

**Blanking:** The strategy is running with 8 clock cycles for blanking.  $\rightarrow 160\text{ns}$ . I could test 180, 200 and 250.

The problem is that the period is 2.6usec. Then we will have a lot of losses. 160ns is a lot already!  $160\text{ns}/26\text{usec}=6\%$

Losses: 92% transmission is from Page 127 BOOK V NIST.

3% loss 99:1 BS

2% loss Splicing

1% loss Lens

1.5% loss Semrock filter

0.5 Loss Mirror

Total transmission 92%

Now if Detector DE=84%  $\rightarrow$  this gives  $0.84 \times 0.92 = 77.3\%$ .

### Check 780 BG counts

1. The power to the 780nm light should be about **160uW-ish**.
2. The way we check it is with the flip mount at the output of the 780nm into the "Receiver Box". This flip mount has a "mirror" that directs the light to the power meter. This

“mirror” is a piece of disk of hard drive with 60% reflectivity at 780nm, and then you see a reduced power. This was used because it is light (however that does not matter.)

3. To check the background counts block the 633nm light and look at the APD output with the FPGA.
4. The APD dark counts are about 10 counts per second (We need to make sure that it is the case by reducing background.)
5. The background counts from 780nm light should be about 25-35 counts per second.

### Calibrate A4

This is the attenuator that is used to go among different MPN. This is not used as an “on-off” attenuator, like the other ones A1A2A3, but rather as a scaled attenuator. About 100nW on the power meter is good enough.

To calibrate A4 we use 3 programs and is done in sequence.

- The first program is calibrating with the power meter.
- The second is using matlab to get the points (attenuations) of interest depending on the strategy.
- The third one is using the trap detector to have a more precise calibration and more accurate error budget.

1. [Power-Meter scan program](#) in [W:\Experiment Programs\State Discrimination Programs\Calibration Attenuators](#)

This program rotates the attenuator while taking data with the power meter and gets the attenuation curve that will be used to find the angles corresponding to the attenuation points of interest. It generates a file that is called “Att4\_CalibrationNonoptimized\_06\_20\_2016.txt”. Change the date and then use it in the Matlab program.

2. [Matlab program example](#) in [W:\Experiment Programs\State Discrimination Programs\Calibration Attenuators\Files](#)

This program loads the text file (Manually change the file name on the 4<sup>th</sup> line and change the Matlab file name) and finds the angles corresponding to the attenuations that you set.

3. The [Rotation Stage program](#) in [W:\Experiment Programs\State Discrimination Programs\Rotation Stages](#) . This program is used with the Trap detector to get a more accurate calibration. It will control the A4 for the angle positions the Matlab program outputs. Once the angles are calculated by Matlab, you go to the program, press **Ctrl-E** and then paste the Matlab output values into the box with the angles. This program is run with the trap detector, so we need to run the [DMV program](#) and the [TIA program](#) for the trap. Use a gain of  $10^8$ .

Once the angles are loaded into the rotation stage program, go to the [Excel Sheet --> Att4](#) in [W:\Experiment Programs\State Discrimination Programs\Calibration Attenuators](#) .

1. Paste the Matlab output angles into the  $\theta$  Att4 column
2. Use the MPN-Angle program to set an angle corresponding to a MPN (Start with #1)
3. Copy/Paste the voltage on the DMV-READ program into the POWER OUT column when the Attenuator is out (Angle of 0) and into the POWER IN column when the Attenuator is in (At one of the Matlab output angles)

4. **NOTE:** Go back to an angle of 0 after each one to avoid any bias
5. Now we have an error % for out attenuation

### Calibrate Polarizations Full Power

At this point we need to check the alignment of the polarizations since this is the critical parameter that we want to optimize over. Go back to CW and check visibility and optimize polarizations. Use Amplification of  $2 \times 10^2$ , otherwise you may see nonlinear and saturation effects that will result in apparent difference in the visibilities of consecutive peaks when looking at interference visibility.

### Calibrate AM

Program depends on strategy, ex:

W:\FPGA Programs\Elohim\ElohimFPGACyUSBMark1\_3\Mark1FPGABinaryVerilogCyUSB\FILES for Strategies\SequentialGlobal\DE 0\_70 Vis 0\_996 DC\_35 (3-11-2016)\Calibration\AMCalibrationWithPhaseCal.rbf

Trigger oscilloscope with the FPGA (this is about 11 kHz).

Lock the PID with the pulsed signal:

1. unlock first,
2. Plug AOM into FPGA.
3. Change the gain of the preamplifier (SRS 560) before the PID (looking at the intensity) by a factor of 2 or 5.
4. Then adjust PID offset to .188 about then lock it. (**gain=2 PID=.072**)
5. At this point, the laser intensity is locked in the pulse mode.

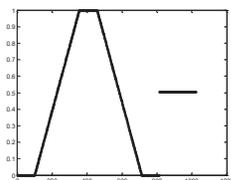
Look at the LO in the oscilloscope using the signal from the “Delay pulse generator” Agilent. Make sure that the settings are correct. To look at the LO at the pulse regime you need to change the settings of the (SRS 560) used to look at the differential detector.

In the CW regime you should use a Gain setting of  $2e2$  with a “Low Pass Filter” at 3kHz with a PI gain corner at 6dBs.

In the pulse regime, you need to use only “CW” mode, which means that no filter is applied.

In the oscilloscope, use an average of about 128 times, to look at the pulse.

Turn on the DAC switch and observe the LO intensity modulation. This should show a ramp up-down and mid level as described in lab notebook:



## Calibrate AM

- Match center two peaks with gain AM when bias voltage =  $\pi/2$  gain at measured mid point when bias voltage 0. Running AMCalibrationwithphasecal on FPGA

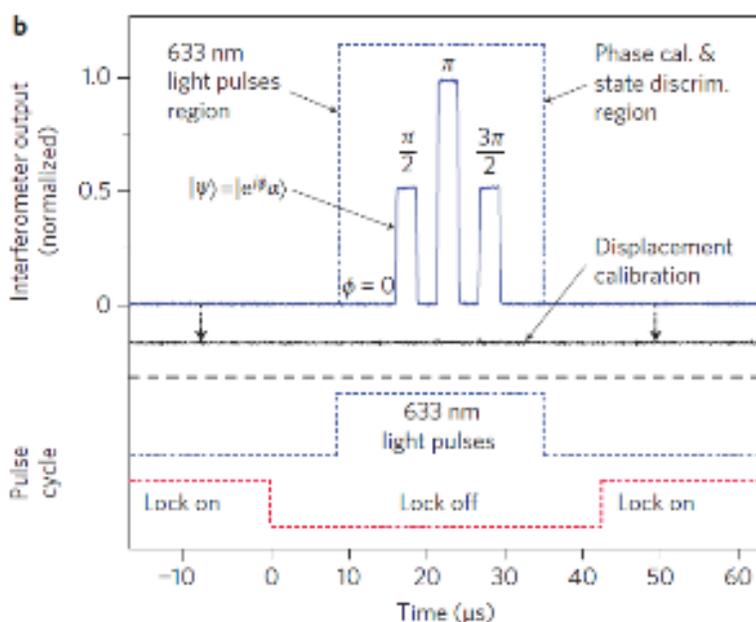
## Calibrate phases Full Power while pulsing.

Pulse and check the height of the Signal and Local Oscillator. Lock interferometer in the pulsed regime.

With the same file that you used for the amplitude modulator calibration you will calibrate the phases. (The DAC should be off at this point). With the FPGA program running, use the MUXs for the phase calibration. Turn on the Signal MUX and check the phases using the interference of the Signal and LO in the pulse regime. They should look like three peaks:

The low level should correspond to Phase=0

The consecutive should correspond to the other phases:  $\pi/2$ ,  $\pi$ ,  $3\pi/2$ .



At this point the Signal phases are calibrated and then you need to calibrate the LO phases. For this, while having the MUX for the Signal on, turn on the MUX for the LO. Then you should be able to "Null Out" all the phases by total destructive interference. (Black line in the figure.)

***At this point everything should be ready to run the tests and the procedure to take data and how to run the strategy will depend on the particular experiment that you are running.***

**Pulse laser and lock with pulse for a given MPN, and calibrate phases**

## RUN TEST!!!

<b>PID SR960</b>	
P	+2.5x10 <sup>2</sup>
I	+1.6x10 <sup>2</sup>
D	off
Up Limit	1.5V
Down Limit	-1.5V

Calibrataion new APD

Calbrate attenuators and ccheck PicoQuant APD:

<b>Picoquant APD</b>	
Counts/Second	82381.4
DC and BG	30 c/s
Sent Light	1e4 c/sec
Loss SR filter	~1.5%
Loss aspheric	<0.5%

<b>DUT APD</b>	
Counts/Second	61500.4
DC	96c/s
Sent Light	1e4 c/sec
Loss SR filter	~1.5%
Loss aspheric	<0.5%

**We are seeing very bad results. We may be seeing something bad. But not sure.**

**Things to do:**

- (1) Check that the FPGA is counting the coutns correctly. Use another counter: the RS 400 for example.
- (2) Calibrate attenuators again and test power.
- (3) Realign the APD with the reflection and with the lens. There may be something that is very misaligned?
- (4) Align old APD and make sure we have the right amount of light and check with the SR400
- (5) Check Tauspad pulse width

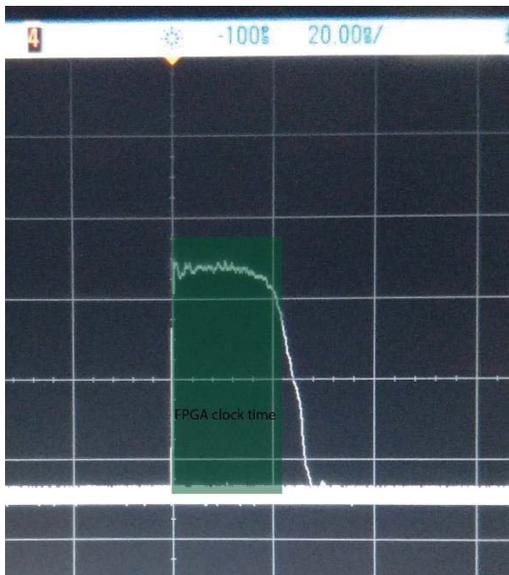
We aligned the new APD and tried to calibrate it. They claim a DE of 96% but we were seeing at most 62% (62,000 counts). We then checked the counts with Andy's SR400 and it was giving more counts, around 80,000(?). We needed to investigate the discrepancy in counting further.

We used Andy's APD and looked at the counts from our FPGA, his FPGA and the SR400 and approximately the same results (our FPGA was off by ~2%). At this point we decided to use the pulse generators with a burst signal to simulate asynchronous pulses that would come from the APD since the problem may be that the SR400 is looking for a repetitive pulse while the FPGA doesn't.

We adjusted the function generator settings in order to see 6000 counts (burst repetition rate of 6 kHz). Andy's APD and the tau-SPAD both have TTL output signals about 20-22 ns long so this is what we set the function generator pulse width to. Andy's FPGA and SR400 gave the right amount of counts (6000) and our FPGA gave ~5900 which is consistent with the 2% loss in our FPGA. We then decided to change the pulse width to 15 ns and found the issue.

The SR400 and Andy's FPGA were still giving the correct amount of counts but our FPGA (with a clock cycle of 48 MHz which is 20.83 ns) was NOT giving the correct amount. If we decreased the pulse width from 22 down by 1 ns then we saw a drop off in the number of counts down to about 4400 at 16 ns which is approximately the same ratio that we were seeing before.

To double check that this was the issue, we looked at the counts from the tau-SPAD in the oscilloscope and saw that they are about 20 ns, which is just long enough for our FPGA to detect them efficiently. So we figured out that the problem is that our FPGA's clock cycle is too slow in order to see all of the pulses from the new APD.



To fix the problem, we need to have a second, much faster clock speed and use that to detect the pulse and stretch it so that the 48 MHz clock can count it accurately.

