1 Introduction:

The main objective of this project is to design a polarization state generator that will be mounted on a mini-table using 1/4-20 screws. The object of the design is to make the system with the proper tolerances as well as the right material so that the system will be able to generate the proper polarization state. The light coming out of the system must be diverging as well.

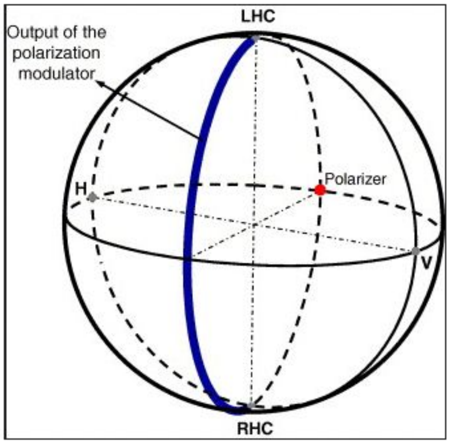

Figure 1: The Poincare Sphere

2 Determined parameters:

Requirement	**Value**	**Comment**
Polarization element diameters	2”	
stage ID	4”	
Laser to Polarizer Spacing	50mm	
Stage 1 to Stage 3 Spacing	50mm	
Laser to Stage 3 Spacing	180mm	
Stage 2 position	between 1 and 3	

3 Requirements:

3.1 Top Level Requirements:

Requirement	**Value**	**Comment**
Laser FOV	14°	
stage resolution	10$arcmin$	
stage range of travel	360°C	
stage speed	N/A	Manual control
Load limit	100 N	
Stage Parallelism tolerance	$< 80\mu m$	
Stage Concentricity tolerance	$< 80\mu m$	
Stage Wobble tolerance	$< 50\mu m$	
Spacing tolerance	$< 20\mu m$	

3.2 Operational Requirements:

Requirement	Value	Comment
Temperature range	$-20°$ C - 50° C	

3.3 Survival Requirements:

Requirement	Value	Comment
Temperature range	0° C - 60°	
Life time	3.10^6 Full turns	

3.4 Limitations:

Requirement	Value	Comment
Box Size	8 x 18 x 7	Portable
Materials	Aluminum 6061 Alloy	Except for purchase part
Weight	30LBF	Portable

3.5 Materials:

Requirement	Value	Comment
Stages	Stainless Steel	OPTO-SIGMA
Custom Patrs	Aluminum 6061 Alloy	
Posts and Post Holders	Stainless Steel	Edmund Optics

3.6 Interface requirements:

The system must be assembled on a mini-table using 1/4-20

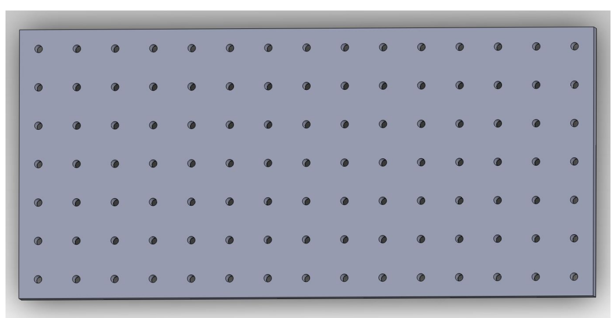

Figure 2: Interface

4 Design Concept:

The figures below show most of the detailed sketches of the system components. The system is going to consist of three stages that will be purchased from OPTO-SIGMA, six posts and six post holders, and a few custom made parts. The custom parts are going to be made using Aluminum 6061 alloy.

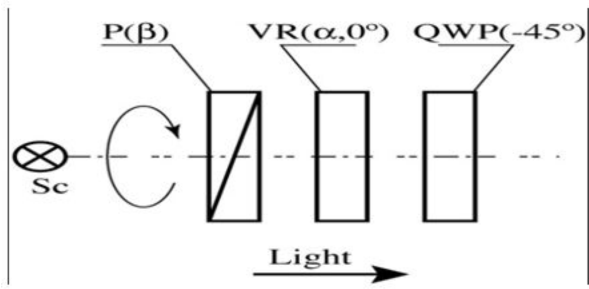

Figure 3: Set up of the PSG

The figure above show how the system is going to set up. The element Sc represents the laser, P is linear polarizer, VR is going to be a linear half wave plate, and QWP is a linear quarter wave plate. The purpose of the linear polarizer is clean up the polarization of the light coming out of the laser. Then the linear half wave plate is going to rotate this polarization state around the equator of the Poincare sphere so that we will be able to get access to all of the linear polarization states. The quarter wave plate is going to move our polarization state along the poles of the Poincare sphere to get all elliptical polarization states.

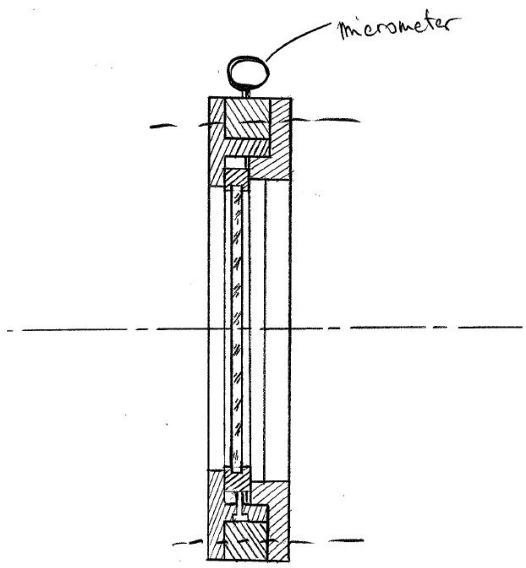

Figure 4: Stage sketch

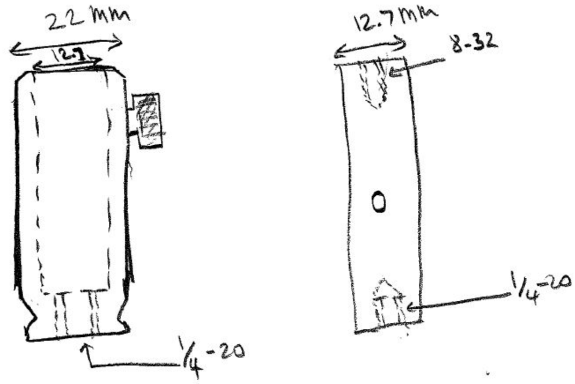

Figure 5: Post and Post Holder Sketch

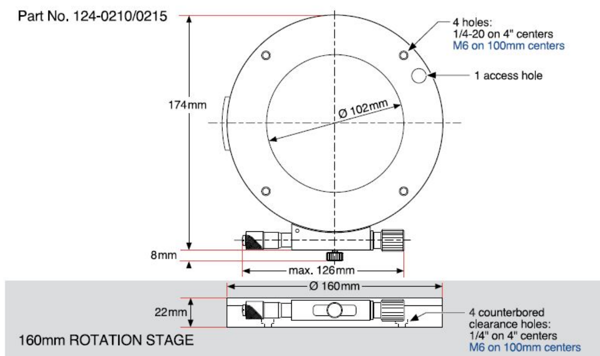

Figure 6: Rotation Stage

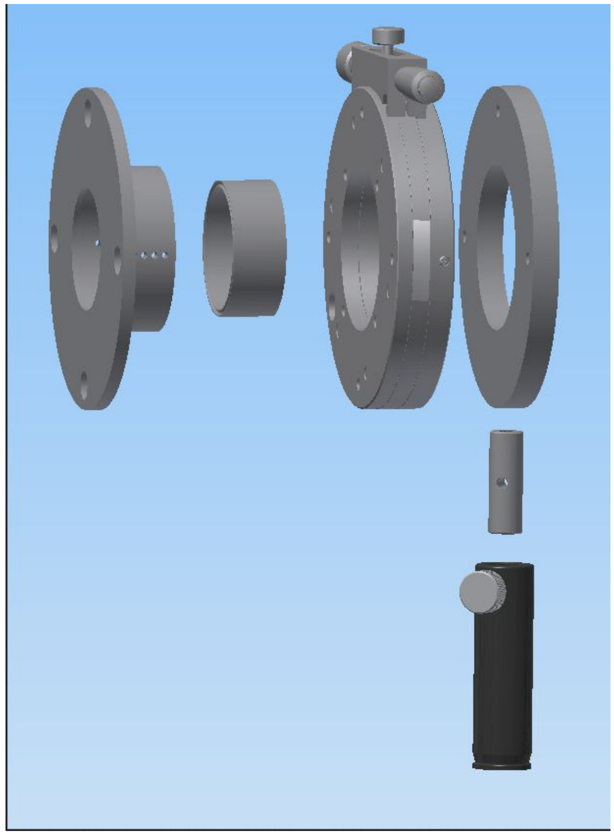

Figure 7: System Assembly

5 Design Preferences:

The choice of the materials to be used for the custom parts is due to the fact the Aluminum is easy to work on and has a very low cost. However the choosing the stages has more to to do with the their performance as well the cost. The table below shows some of the parameters of the stage:

Requirement	**Value**	**Comment**
stage resolution	$5arcmin$	
stage range of travel	360°C	
stage speed	N/A	Manual control
Load limit	196.0 N	
Stage Parallelism tolerance	$< 60\mu m$	
Stage Concentricity tolerance	$30\mu m$	
Stage Wobble tolerance	$< 30\mu m$	

6 Budget:

Part	Unit Cost	Quantity
Stages	795	3
Custom insert 1	450	3
Custom insert 2	350	3
Custom adapter ring	350	3
Standard post	20	3
Standard post holder	30	3
mini-table	1000	1
Polarizer	300	1
HWP	500	1
QWP	500	1

The total price comes to 4295 dollars

7 Preliminary Calculations:

Since we want to the exiting beam to be diverging, we need to determine the maximum distance between the laser and the entrance surface of the last polarization element FFOV = 14° D = 2in = 50.8mm

$$L_{max} = \frac{D}{2}\frac{1}{tan(7°)} \tag{1}$$

$$L_{max} = 206mm$$

To determine the life time of the stages, we need to know the total of the custom parts and the polarization elements. Since the QWP weighs the most, we will used it to detemine the minimum life time of the stages.

$$M_{total} = M_{QWP} + M_{CP} \tag{2}$$

$$M_{total} = 2kg$$

The equation to determine the life time of the stage is defined as follow:

$$L = 50\frac{C^3}{8P^3} \tag{3}$$

L: Running life time (km)
C: Static allowable load 100N
P: Imposed load

$$P = M_{total} * 9.81m/s^2 = 19.62N$$
$$L = 827.53km$$

$$L = 2\pi\frac{D}{2}n \tag{4}$$

n: Is the number of rotations Solving for n, we get:

$$n = 5.2.10^6$$