Niobium Metal Underwater Connector

Senior Design I

Fall 2014

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Background

- Company: Northrop Grumman

- Customers
  - Navy
  - Air Force
  - Satellite Company
  - Department of Defense

- Technology:
  - Automated vehicles (Surface & Undersea)
  - System Integration
  - Advanced Sensors & Sensor Processing

Problem?

- Unmanned Underwater Vehicles (UUVs) powered by onboard batteries
- UUV survive underwater for a certain amount of time due to battery life
- No way to keep onboard batteries charged while underwater
- Length of UUV mission lives dependent upon the capacity of the onboard batteries

Is there a way to solve this? Can we create a mechanism to lengthen battery life, or can we create something innovative?

Our Innovative Thinking

These missions may potentially be lengthened if there existed a reliable method of *underwater remote charging* for the batteries onboard the UUV.

Problem Formulation

Objective

- To develop a two contact wet mate electrical connector
- Utilizing Niobium (or Tantalum) metal as primary contacts between the two platforms.

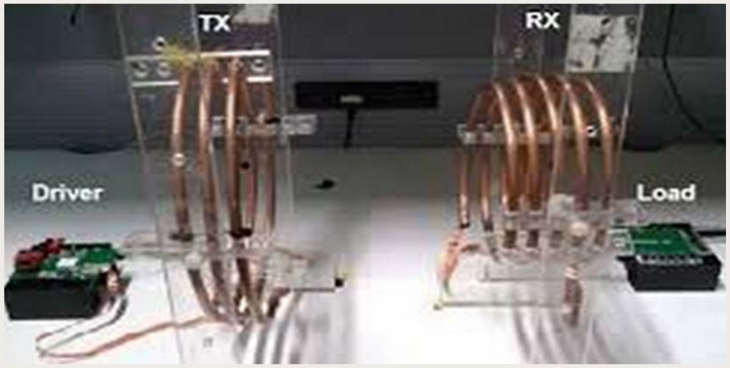
Benefits of Niobium Metal

- Niobium Self-Insulating Property (no need for seals)
- Pin contacts exposed to water without any potential detriments.

Current Status of Art

<u>Wet Mate Connector & Underwater Power Circulation</u>

- Current wet mate connectors rely on complex sealing and wiping mechanisms (proven unreliable).
- Current Complex Inductive Coupling technology for power circulation has significant loss, large in size and weight (a hassle).

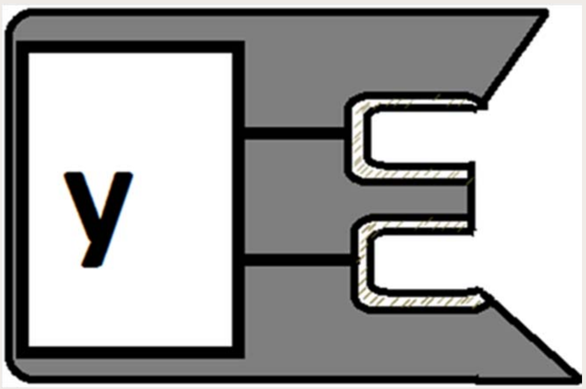


Design Requirements

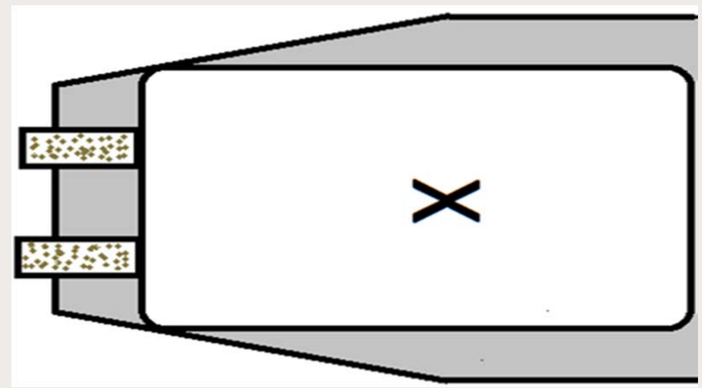
- Input Power: 48 V DC, 25 A
- Capable of functioning in seawater as well as fresh water (>= 100 meters deep)
- Capable of functioning in temperatures between -2℃ and 50℃
- Surviving in temperatures between -40℃ and 70℃
- Capable of spending 25 years submerged in seawater
- Capable of carrying a 2.4 or 5GHz 802.11 signal across the connector

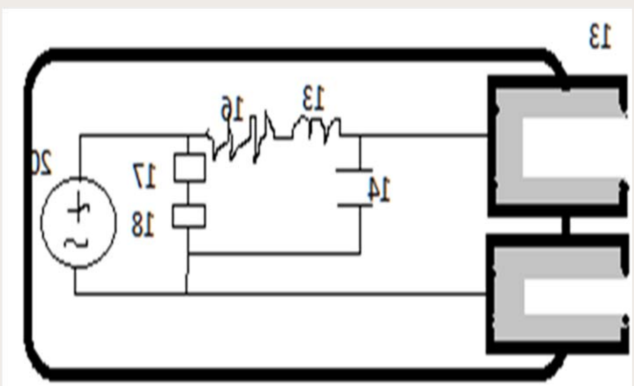
Solution Approaches

Solution A - Direct Contact

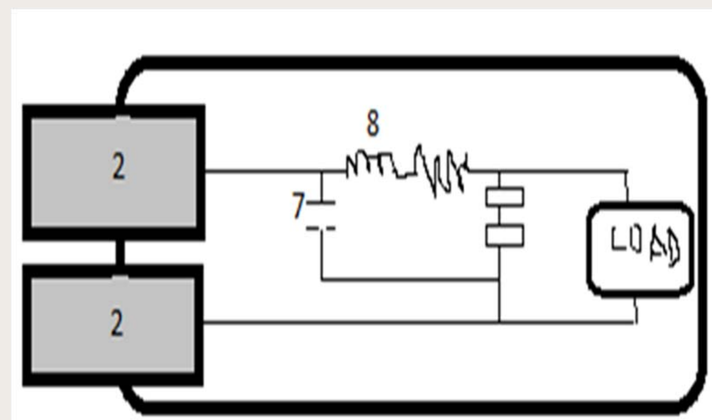


Charging Station





Unmanned Underwater Vehicle



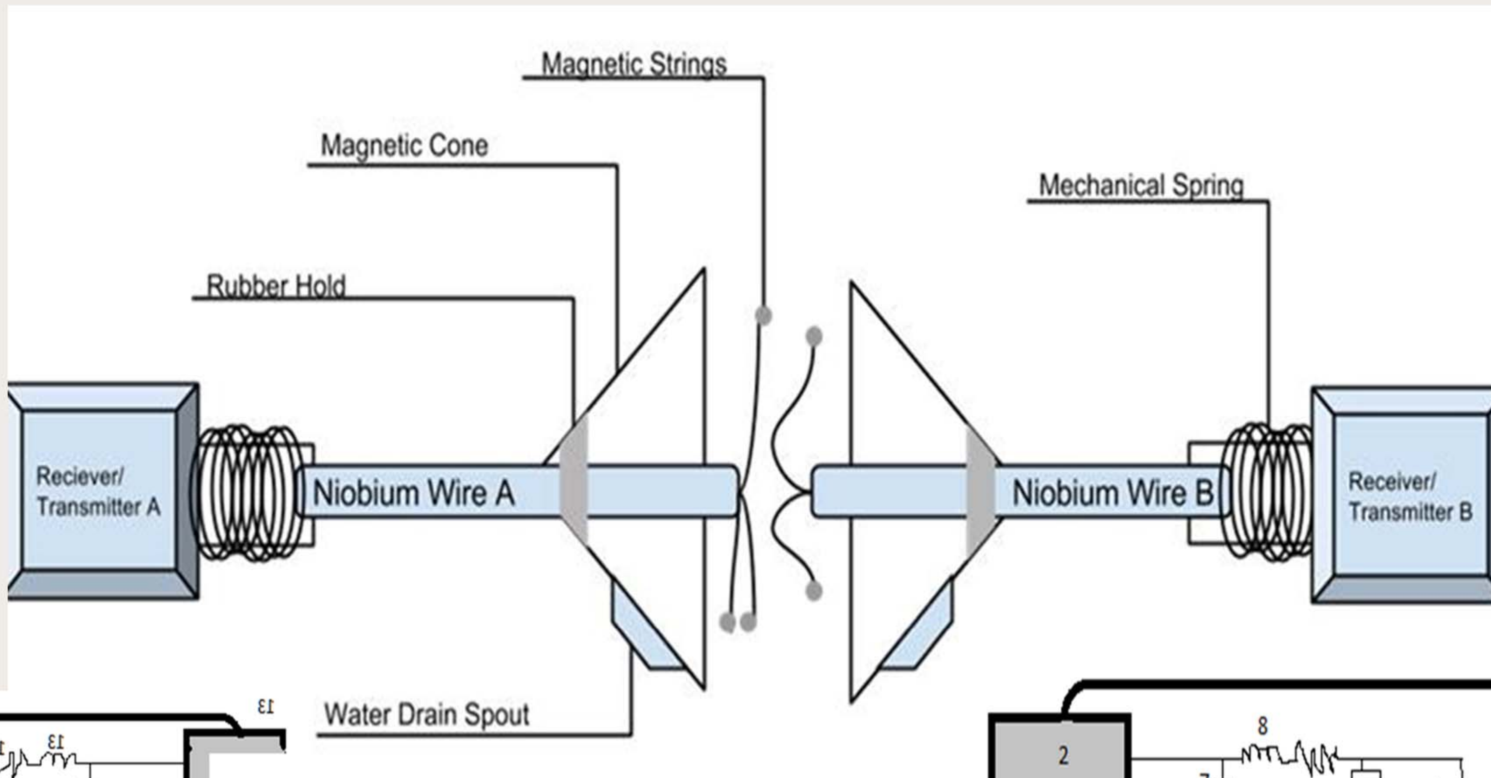
Solution Approaches

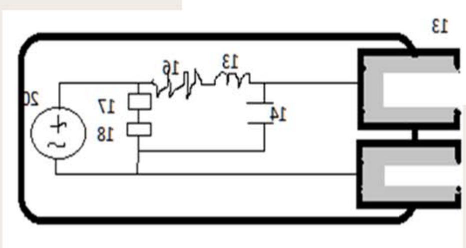
Pros & Cons A

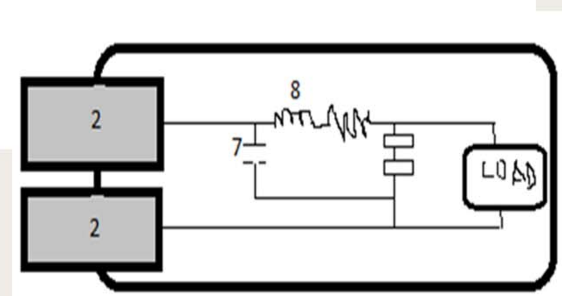
Pros	Cons
Direct connection leading to less power loss	Aquatic wildlife (plants & animals) interfering with connectors
Sensors will assure perfect alignment & connection	One connector damaged, machine rendered useless
End shape of conductors enable a solid connection	

Solution Approaches

Solution B - Magnetic Cones







Solution Approaches

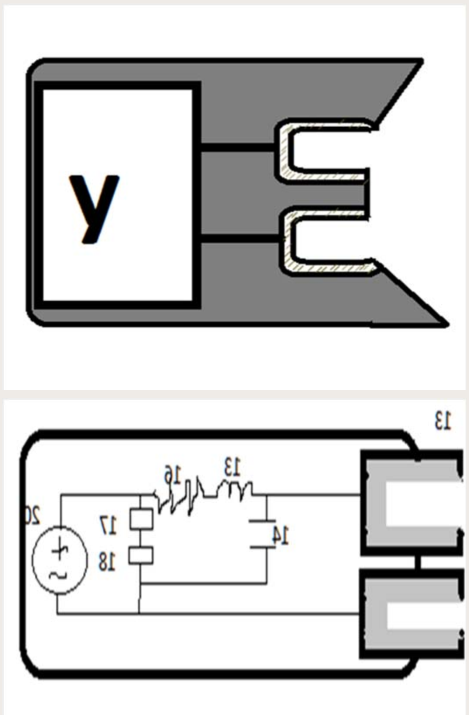
<u>Pros & Cons B</u>

Pros	Cons
Transfer of energy is well established	**Power & signal experience loss due to the magnetic cones**
Guarantee of connection due to magnetism	**No connectivity due to buildup on magnetic strings**
Drain Spout assure no excess water will damage mechanism	**Water drainage blocked or clogged from outside interference**
	Pressure from sea causing mechanism to not work
	Magnetic strings could be malleable

Chart Measuring Each Attribute For Both Prototypes

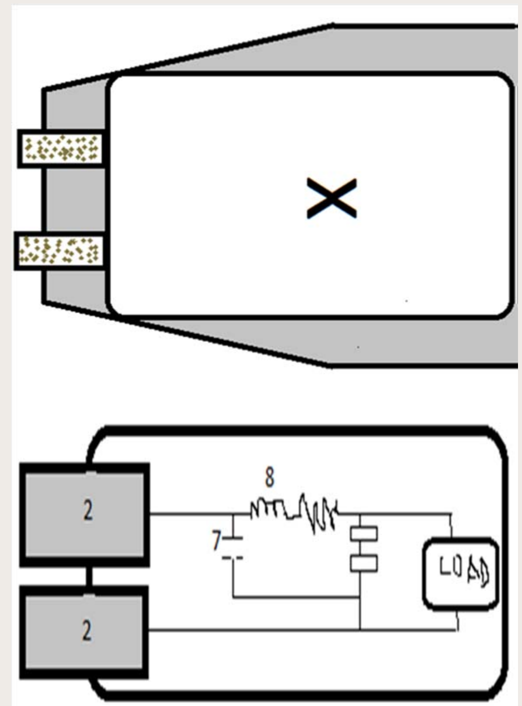
	Weight	Prototype A	Score	Average	Prototype B	Score	Average
Charging Time	5	The direct alignment	4	20	Interference with magnets can alter the charging flow	3	15
Voltage/Current	4	48 V DC	4	16	48 V DC	4	16
Connectivity	5	Positive and negative pins defined	4	20	The possibility of short circuit with the magnetic string	2	10
Material Used	6	Niobium	6	36	Niobium & Magnetic string	6	36
User Interface/ Connection	5	Connector with pins to connect each side	5	25	Connectors with magnetics cones & strings	4	20
Sensor	4	End of UUV and Charging Station	3	12	No use	3	12
Total	29		26	**129**		22	**109**

Final Product



Charging Station

Unmanned Underwater Vehicle



Addition

- Radio Frequency signal generator (flow along the Niobium surface)
- Radio Frequency receiver
- Microprocesseur

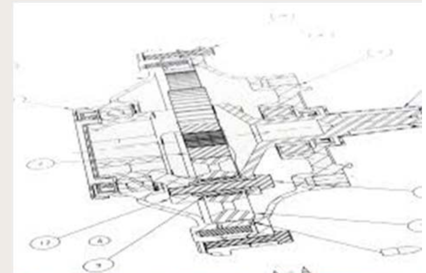
Implementation & Evaluation

1. **<u>Construction of CAD Bias Tee Design</u>**
   a. Very detailed overall design
   b. Circuit Simulation
   c. Mechanic Simulation

1. **<u>Collection and evaluation of Materials</u>**
   a. Evaluation of necessary electrical components
   b. Measurements and estimations of most optimal parts.
   c. Management of budgeting and cost efficiency

1. **<u>Manufacturer</u>**
   a. Brings CAD design to life
   b. Assembles and constructs materials
   c. Stress-testing and material integrity

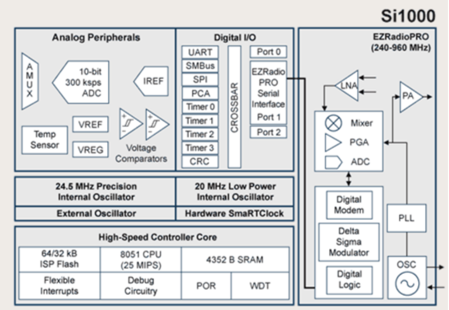
1. **<u>Scheduling and Task Management</u>**
   a. Weekly task descriptions and Milestone determining
   b. Keeping pace with Northrop Grumman requirements
   c. Keeping pace with Senior Design II requirements



Suggested Programs & Devices

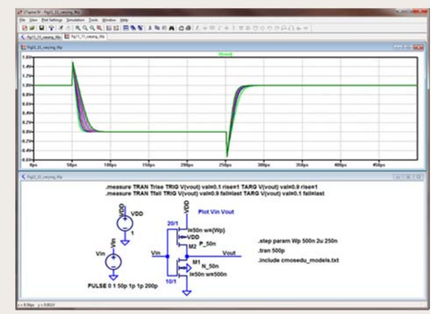
Devices

- Wireless Connectors for microcontrollers
- Silicon Labs Si1000 Microcontroller
- Niobium light-bulb connector
- Voltage/Power Distributor



Software

- LTSpice - circuit simulation and part-testing
- CAD - overall mechanic and visual design
- Wireless connection program



Environmental Elements

- Salt for seawater simulation
- Liquid Epoxy for extra underwater protection
- Spare metals to compare to niobium

Planned Schedule

January

PARTS AND FURTHER DETAIL RESEARCH FOR PROTOTYPE			
1-10	11-17	18-24	25-31
All Members	All Members	Joshua	Crepin
Research	Order parts & components for prototype	Test parts and implement parts into design	Visit Annapolis to meet with Northrop Grumman

February

BASE CASE OF PROTOTYPE			
1-7	8-14	15-21	22-28
All Members	All Members	All Members	Kerri
Assemble Prototype	Assemble Prototype	Test prototype to see if it works	Analyze prototype to see if there are any problems or mishaps

Planned Schedule (Continued)

March

FINAL CONSTRUCTED PROTOTYPE TO PRESENT				
1-7	8-14	15-21	22-28	29-31
Project Manager	Project Manager	De'Shawnn	All Members	All Members
Test Prototype at Northrop Grumman Facility	Test Prototype at Northrop Grumman Facility	Analyze results from test to assure machine is reaching goal	Prepare for final presentation and ECE day	Prepare for final presentation and ECE day

Cost & Resources

Budget of $10,000 to be used for:

- Niobium Bars
- Microprocessors
- 3D Printing
- Bias Tee

The following resources that will be used for the development of the project are:

- ***Howard University laboratories & facilities***
- ***Northrop Grumman laboratories & facilities***
- ***Sources obtained from advisors, the internet & local libraries***.

Conclusion

Team UCC plans to achieve our projected goal to ***fully assemble and develop a functioning prototype of the two contact wet mate electrical connector*** by the end of Senior Design II in Spring 2015

By doing the following:

- Pulling from existing methods of underwater connection
- Proper research and planning for the materials, tools, and techniques needed.
- Using our design requirements and final design to reach our end goal
- Implementation of the “Direct Connection UUV-to-Charging Station” conceptual design
- Proper Project Management, completion of tasks, producing appropriate deliverables

Thank You!