Welcome to my demonstration professors. Today I’ll be explaining and showing off some of the hard work I’ve done this year on my project. My project has been entitled generating power in extreme environments for remote applications, which is a mouthful I know. Which in slightly simpler terms means powering a device without batteries.

Now this title leaves a lot to the imagination so the specific aims of my project were as follows: Investigate an extreme environment; Find a suitable way to power some device and design a solution for it; and the goal upon completion is to have a well thought out design that could be built and used in the real world.

So I looked at a few environments such as coal mines and high altitude, however I settled on deep sea due to a personal interest in it through surfing.

What I found out was that the sea covers approximately 75% of the earth’s surface and yet most of it remains unexplored and unknown due to the harsh conditions down there. For example there is no air for humans to breath, the pressure increases one atmosphere for every 10m down you go and the temperature declines rapidly with depth.

Thus a perfect application was an undersea explorer robot, a robot that could stay underwater for indefinite periods because it could generate its own power. The robot could send back images of what it find or information wirelessly.

Before this idea could really begin to take shape though, a method of power generation was needed; and this of course is the key part of the project. I looked into four different sources of power, pressure, temperature, chemical and kinetic and I settled on kinetic for various reasons using a turbine to harvest energy out of underwater currents.

At this point it was important to make a more exact specification of the scope of project so that the project would be realistic for the timeframe: The specification, said that the robot must be able to withstand the undersea environment, ie the temperature, pressure, and salt water, while generating its own power. I also put in some simplifications which would be expected in a normal robot that would be addedd once the initial design was proven. The robot would have no turning, ie it only goes straight. No remote control, it just goes when power is given, idles otherwise and no video cameras or sediment testers.

So with the scope sufficiently narrowed I was able to start work and I came up with the following design: this flow chart shows a very simple overview, with the turbine spinning the generator which passes power through a power converter to the motor to power the wheels. We also see the design concept that I came up with in the end.

We’ll note here also how I intend to combat the environment of the sea. The robot must be completely water tight to stop the sea water from getting inside the robot and interfering with the electronics. However at sea the pressure increases by 1 atmosphere every 10m and thus if the robot is filled with air it will be crushed. The solution is a non-compressible liquid, however it must also be non-conducting and oil is a perfect choice. The other issue is the corrosive nature of sea water and to combat this the exterior of the robot will be made from plastic. Finally to combat the soft sediment found on the seafloor the robot shall utilize tank tracks to spread the weight evenly so as to stop sinking and maximize traction.

Given this equation here we can see that the amount of power given from the turbine is governed by the size of it, and when the correct numbers a plugged in the diameter of the turbine is found to be 23.8 cm. I haven’t put it on the slide there but the efficiency I use in the equation is only 0.3 this is because the Betz limit says that the maximum possible with a turbine that is not shrouded is only 0.6.

The generator that I have used in this project, had only motoring characteristics and I chose it simply because it was already in the department. So in order to get some generating characteristics I needed to perform some tests. So I set up a test set and put a resistance on to model the load, I used three resistances, 0.5,1 and 5Ω and the different results are shown on the graph. What is clear is that for a lower resistance more power is produced. It should be noted that this is a single phase representation so to get three phase we must multiply by root 3. After these tests I did open and short circuit tests to develop a single phase equivalent circuit which is shown here.

So the testing the generator gave us these three helpful points of information, the maximum output at 0.5Ω is 70W three phase, the speed required at 0.5Ω is 2400 rpm to get the 25W we require. And the voltage and current are 4.7V and 5.4A.

Using these results we find that the gearbox must have a ratio of 19:1 as the turbine is estimated to spin at 124rpm. The power converter must convert the 4.7V, 5.4A AC wave to 5V, 2A DC. To do this the power converter is to be made of three phase bridge rectifier following by some DC bus capacitance to stabilize the wave and regulated by a buck-boost converter. Finally to get the 0.5Ω resistance that I modeled at the output motors can be paralleled to give a resistance of 0.36Ω where the power converter resistance.

In conclusion I have completed what I set out to do, that is making a preliminary design for an underwater robot. However if I was to build this robot I would need to do a few more steps, which would require me to build a bit and test a bit. I would need to build up the tank tracks and then find exactly what voltages and currents need to be supplied to the motor s to run them. Then I would need to choose the power converter and slowly build and test the device to ensure it all worked together. The final test would be done in a water tunnel to simulate a current and a success would be given by the robot moving against that current.