3.0 ROV Thrusters & Propeller Attachment

3.1 Propulsion

ROV’s move forward and back, up and down, and to the left and right. They can make all of these moves without the benefit of a rudder. With three strategically placed motors each of these degrees of movements can be performed. Two of the motors are installed facing to the front of the ROV, one on the port side and the other on the starboard side. If both of these are powered in the same direction at the same time the ROV will move forward in a straight line. If the polarity of the motors are reversed, so will the direction of the ROV movement, and it will move backwards.

To make the ROV turn to the left, the starboard motor is pushed forward, and the port motor reversed. The asymmetry of the motor movement will cause the ROV to turn to the left. If a right turn is needed, the left motor will be pushed forward and the starboard motor back.

The up and down movement is effected by a motor that is positioned vertically on the ROV frame. With the ROV slightly positively buoyant, when power is applied in the “down” direction, this thruster will cause the ROV to dive. When power is applied to the thruster in the “up” direction, the ROV will (should) return to the surface.

3.2 The Motors

Bilge pump cartridges are used as the ROV thrusters. Bilge pumps are normally used to remove water from the inside of a boat. They are built to be waterproof. Bilge pump cartridges are the working pump part of a bilge pump. The cartridges are sold separately from the Bilge Pump kit and are used to replace the pump which commonly wears out after several seasons of work. They are simple to modify for use as a thruster for an underwater robot.

In Figure 3.1 is an unmodified, “off the shelf” bilge pump cartridge. It consists of the electric pump and an impeller which is designed to remove water from the bottom of a boat. In some bilge pump cartridges, the impeller is protected by a cowling. If the bilge pump cartridges you’ve procured have this, it can be removed by cutting around the cowling with a hack saw. Johnson bilge pump cartridges do not have a cowling, or cover, around the impeller. Bilge pumps are rated by how much water they can remove from a boat in an hour. A 500 gph (gallons per hour) has been found to be ample for ROV’s in a bucket. These can be found at a local boating supply store (West, Overtons, or Boaters World) for around $13/each.
3.3 Propeller Attachment

If present, the first step is to remove the cowling from around the impeller. Next, grasp the impeller with a pair of pliers and pull it from the shaft (Figure 3.2). Do this to three cartridges, and put them aside for the moment.

The next step is to fasten the propeller to the bilge pump cartridge shaft. This is accomplished using a direct drive propeller adapter offered by master air screw (www.masterairscrew.com). Each of these adapters comes with all of the pieces necessary to securely fasten a propeller to the bilge pump cartridge shaft.
Propellers: Propellers can be purchased at a hobby store. For this ROV the diameter of the propellers from tip to tip is 2.5". The hub, or center point where the Prop Adapter bolt threads through is 3/8" of an inch. You’ll need 3 propellers. It is handy to have a couple of extra propellers around in case one breaks or happens to spin off and is lost underwater. Lost propellers are easily retrieved using the pool net and then reattached. The propeller diameter and the angle of the blade (pitch) will determine how fast the ROV moves. The larger the diameter, the more blade there is to push the water. The drawback is that the greater the diameter, the larger the frame has to be to separate the motors and also offer protection from obstacles (see frame). If they are too close together the props may hit their blades.

Pitch is measured by the distance a propeller will move a boat with one complete turn of the propeller. The greater the pitch the greater the “bite” of the propeller and the further the boat will move with one complete revolution.

There are inexpensive, workable alternatives to purchasing expensive propellers from a hobby store (They run, on average $5/each). Inside every computer, or electronic device there is usually a small fan used for cooling electrical parts. In the “industry” these are called “muffin fans”. Using the Internet the author was able to find an industrial manufacturing company that imported these by the tens of thousands for the manufacture of muffin fans. With a couple of phone calls and short, descriptive emails an importer became excited about the intended use of their product and mailed over a thousand at no cost. These are not the most efficient propellers, but they serve the purpose of providing the thrust necessary to move the ROV’s forward, back, and up and down.
Figure 3.4 shows the front and back of a 4-blade muffin fan used in this “thruster” build. On the left is the hub that the hub bolt will be inserted into. The hub bolt should have a flat washer between it and the plastic hub base. The image on the right shows the backside of the propeller. This is side of the propeller should face the prop adapter.

Figure 3.5 shows the hub bolt and flat washer being inserted into the propeller hub.

Figure 3.5: Thread the hub bolt through the propeller center.
The hub bolt is inserted into the propeller center and is now ready to be threaded through.

**Figure 3.6: Hub bolt & washer- ready for tightening**

Using an allen wrench, thread the hub bolt through the propeller hub until the bolt and the flat washer have been pushed against the propeller hub. It is now ready to be attached to the prop adapter.

**Figure 3.7: tighten the hub bolt with the allen wrench**
In **Figure 3.8** the hub bolt has been threaded through the hub and is now flat against the prop hub. In the next step, the prop will be attached to the prop adapter.

**Figure 3.8**: The prop bolt has been advanced so it is against the prop hub.

**Figure 3.9** shows the propeller turned on its edge so you can see the threads of the hub bolt have passed through the propeller’s center. There are plenty of threads available to screw into the prop adapter.

**Figure 3.9**: The prop bolt threads are all the way through the hub.

**Figure 3.10**: Grab the propeller and thread the prop bolt into the top of the prop adapter.

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**Figure 3.11:** Spin the propeller into the prop adapter hub.

**Figure 3.12:** Put a thin piece of cloth between the jaws of your pliers and hold the prop adapter between the jaws. I have a set of water pump pliers with plastic cushions fastened around the jaws. The cloth or jaw cushions keep the prop adapter from getting scratched during this procedure. While holding the prop adapter firmly, torque the allen wrench in the hub bolt to make sure the propeller is snugly connected to the hub.

**Figure 3.13:** Grab one of the bilge pump cartridges. In Step 2 (Figure 3.2) you pulled the impeller off of the shaft. Now, note that the shaft is not perfectly round, it has a flat surface.
Pick up one of the prop adapters. Note the set screw that should be inserted into the threaded hole on the side of the adapter (Figure 3.14). Thread the set screw onto the adapter. Looking through the bottom of the adapter, make certain that the tip of the set screw does not come through the cylinder wall. You’ll need this cylinder clear so you can slide it easily onto the bilge cartridge shaft.

**Figure 3.14:** turn the set screw until it won’t come out of the adapter cylinder, Make certain that the tip of the set screw has not come through the adapter’s interior shaft wall.

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**Figure 3.15:** Slide the propeller and prop adapter assembly onto the bilge pump cartridge shaft. Align the shaft screw with the flat edge of the cartridge shaft.
Figure 3.16: Slide the prop down so that it is just above the flat surface of the bilge pump cartridge plastic case. Don’t push the shaft against the top of the bilge pump cartridge. There needs to be a smidge of space between the cartridge top and the hub so that it will spin freely.

Figure 3.17: Make certain that the shaft set screw is aligned with the flat blade. Tighten the set screw with the little allen wrench. Don’t over tighten. If too much torque is put on this allen wrench either the set screw or the wrench might break. Put the allen wrench in a safe place. When you are using your ROV in the water you should make a practice of checking the tightness of the set screw. This will prevent the prop from coming off during operation.
**Figure 3.18:** This thruster is now ready to be attached to the ROV frame. Attach the propeller assembly to three thruster motors. In the next series of steps we'll show you a way to integrate the motors into the PVC frame.