Ice Core Collection Experimental Device (ICCED)

Micro-g NExT Under Ice Sampling Device

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Abstract

The Ice Core Collection Experimental Device (ICCED) is designed for participation in the NASA Microgravity Neutral Buoyancy Experiment Design Teams (Micro-g NExT) “Under Ice Sampling Device” challenge. This challenge involves the design, development, and testing of a sampling device that will interface with a submersible vehicle in order to obtain subsurface ice samples in an underwater environment. ICCED is a remotely controlled, underwater drilling device designed to excavate and extract ice cores of 0.5 inches in diameter and 3 inches in length. ICCED consists of a drill connected to a linear slide, which is controlled by a microprocessor and is able to cut through ice with the help of attached blades and a servo to power the drill. This device is designed for operation in environments such as those present on the moons of Europa and Enceladus, during which it will be able to drill into an ice surface, collect a sample, and secure the sample inside an insulated module.

Linear Slide

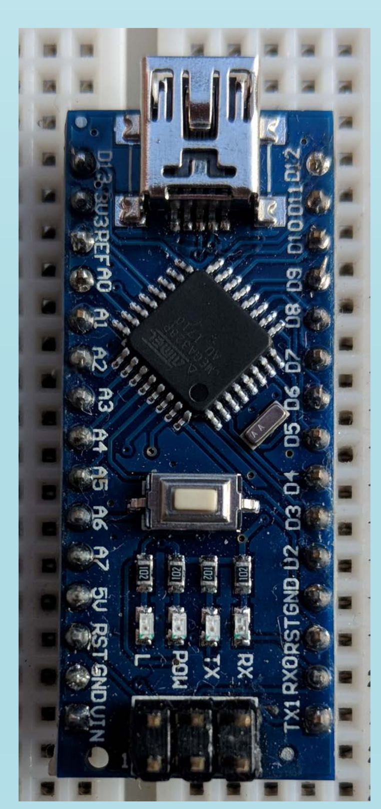
Above: Servo and attachment that controls the linear slide.
Right: Fully extended linear slide.

The linear slides are made from 10x10mm Makerbeam black anodized aluminum beams. The slides consists of two 4” long segments of beams connected end-to end connected to a 4.5” long beam segment that is attached to the storage tube. These segments work together to fully extend the drill 5” to the surface of the ice and an additional 3” into the ice to drill and collect a core sample. Along the sides of the linear slides are 6 0.5” ball bearing pulleys that have a 1mm kevlar line threaded through the pulley tracks to control the extension and contraction of the slides. To prevent the line from sliding off the pulleys, pulley “shields” have been installed to keep the line aligned in the tracks of the pulley wheels. A servo is connected to the bottom of the linear slide to control the length of the line for the extension and contraction of the linear slides.

Electronic Systems and Device Control

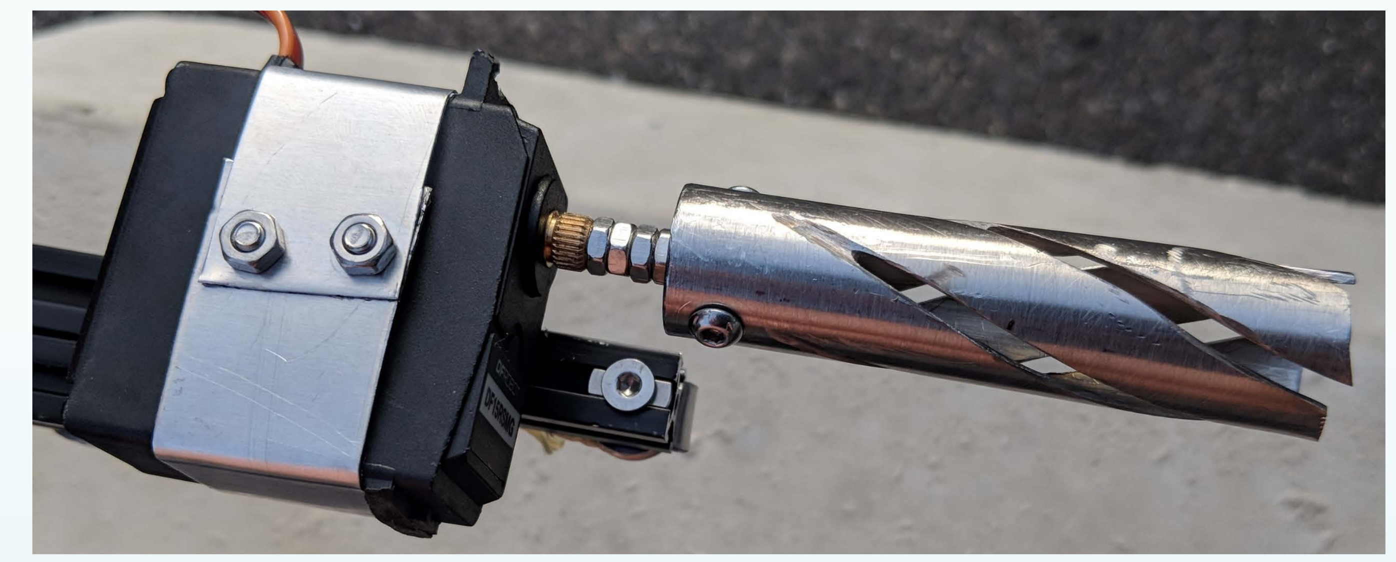
The microprocessor being utilized in the drill is an Arduino Nano, which is 18mm x 45mm. The Nano has an operating voltage of 5 V, and accepts an input voltage within the range of 7-12 V. The Nano is programmed to interface with a human operator. The human operator will have a selection of various methods to choose, which will allow the linear slide to extend, to retract, and allow the drill to start twisting. This feedback process will be connected through the use of a Mini-B USB cable that runs from the Arduino Nano to the controlling computer. The Nano will be powered via general purpose input/output lines that are provided by the NBL and supply up to 12 V.

ICCED uses two servos to control the overall movement of the extension of the drill bit via the linear slides and the rotation of the drill bit. For the linear slide, the servo is the FEETECH FS90R 360° continuous rotation servo, with dimensions of 1" x 0.9" x 0.5", weight of 10g, and a rotation speed of 110 RPM at 4.8v. This servo acts like a winch, winding the line of the linear slides or releasing the line. The line is mounted so that when spinning the servo in one direction the linear slide pulls the line to extend the slide out of the device, and when spun in the opposite direction, the line allows the linear slide to retract back in by the weight of the linear slides and drill. The second servo controls the rotation of the drill, and is attached to the side and at the end of the linear slide mechanism. The servo used is Digital Metal Gear Servo 360° Clockwise/Counterclockwise Continuous Rotation Servo. This servo has a torque rating of 20kg*cm at 4.8v with a rpm of 60. This servo is located at the end of the linear slide, and directly powers the drill bit.



Arduino Nano used to control the device.

Fully extended drill design.



Left: Drill Bit connected to its controlling servo. Right: Close up view of drill bit teeth.

Drill Bit

The drill bit is constructed from a ⅝” inner diameter ⅛” wall thickness 317L stainless steel tube. The drill has spiral slots in the exterior to allow the chips be transferred out of the hole during drilling. The drill bit has incorporated teeth at the top at an approximate angle of 60 degrees.

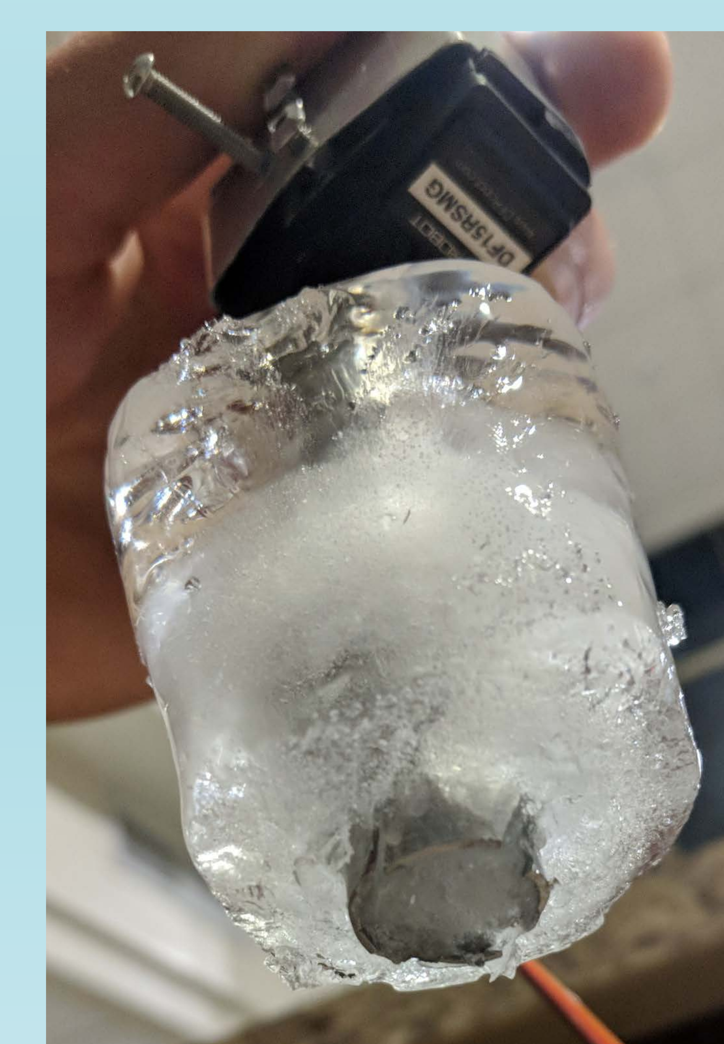
Overall storage unit.

Overall Storage Unit

The overall storage unit is a cylindrical fiberglass, resin composite tube 6” long with an internal diameter of 2.975” and an approximate exterior diameter of 3.095”. The fiberglass tube is lightweight, electrically insulative, high strength to weight ratio container that will house and store all of the components of ICCED. Within the storage unit, there is an additional cylindrical tube that the device is securely attached to, and this cylindrical tube is securely attached to the fiberglass with epoxy. The storage unit is closed off at the one end with a attachment plate that is compatible with the work platform at the Neutral Buoyancy Lab in Houston. The opposing end of the device is where the drill bit will extend on linear slides and collect a core sample before retraction.

Testing and Analysis

Testing of the device was done through the testing of individual systems on the device and the overall device. The systems were assigned as follows: electronics, linear slides, drill assembly, encasement. Each system was tested multiple times throughout the build process to ensure there were no faults or unexpected outcomes. After individual component testing, the systems will be assembled into the final device and tested altogether in a simulated testing environment. This final series of tests will consist of submerging the device up to 14 feet underwater in the ERAU campus pool, and drilling into an inverted block of ice.



Example of a successful drill test, with core sample inside the drill bit.

MICRO-G NEXT
Neutral Buoyancy Experiment Design Teams