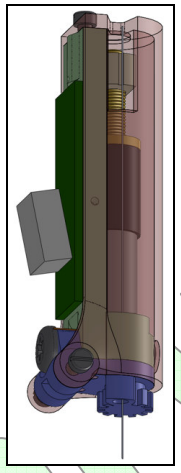
RP Metrix

Single Microdrive Headstage and Kits | ND1HS1K

Lightweight Motorized Neural Probe Headstage and Headstage Kits for Awake Animal Neural Recording



- **Single motor microdrive**
- **~1.5 gram total microdrive mass**
- **~3000 µm travel in 0.27 µm steps**
- **Omnetics Nanominiature connector for**
  - **4 microelectrodes**
  - **1 reference signal**
  - **1 stimulus signal**
  - **3 independent motor control signals**
  - **1 ground reference**

Ordering Information

Description	Part Number
Assembled single motor microdrive	NDIHS1-x
Kit, Complete headstage, with motor	SMDK1-x
Kit, Complete headstage, without motor	SMDK2-x
Kit, Consumable headstage parts	SMDK3
Motor (MicroMo 0308A003B+03A 125:1S3)	SMDM1
Headstage PCB and connector	SMDP1-x
Kit, Reusable Tool Set	SMDT1

Note: For assembled microdrives or kits, please replace "-x" to indicate the printed circuit board (PCB) option (see Fig. 3). For example, to order a 4-channel microdrive kit with motor and 10-pin connector, order item SMDK1-B29.

Itemized Headstage Kit Contents _____

Item	SMD K1	SMD K2	SMD K3	SMD P1	SMD M1
Motor and Gearbox	1	0			1
Plastic Body	1	1			
Plastic Base	10	10	10		
Plastic Shuttle, pretapped	10	10	10		
Plastic Cover	10	10	10		
Threaded Lead Screw	1	1			
Printed Circuit Board (PCB, select one, Fig. 3)	1	1		1	
Omnetics connector, matching PCB	1	1		1	
Cover Screw (000-120)	3	3			
Base-Body Screw (0-80)	1	1			
Stainless Steel Dowel	2	2			

Tool Kit Contents _____

The items in this tool kit can be obtained directly from the listed suppliers.
We provide this kit as a convenience. The tools can be reused to assemble many microdrive kits.

Item Description	Part Number	Supplier	Website
Swivel Cap Pin Vise, 0"-.125"	8455A31	McMaster	mcmaster.com
0.047” Slotted Head Screwdriver	52985A34	McMaster	mcmaster.com
T5 Torx driver	52995A23	McMaster	mcmaster.com
Tap, 0-80, H1 HSS Taper, 2-FL	2522A751	McMaster	mcmaster.com
Tap, 000-120 GH2 HSS, 2-FL	000120HS2G2G	J.I. Morris	jimorrisco.com

Third Party Supplies _____

Chemicals, liquids and supplies suggested in this document can be ordered directly from the suppliers listed below.

Item Description	Part Number	Supplier	Website
Kester solder flux pen, 2331-ZX	KE1808-ND	Digi-Key	digikey.com
Loctite, Hysol, 1C-LV filled epoxy	6430A35	McMaster	mcmaster.com
Adhesive Dispensing Gun, 1:1 & 1:2	74695A71	McMaster	mcmaster.com
Bayonet Mixer Nozzle, 2.9"L, 3/16" Blunt	74695A56	McMaster	mcmaster.com
PlastiDip synthetic rubber coating	---	Home Depot	plastidip.com

Specifications

Characteristic	Symbol	Min	Typ	Max	Unit
Gearhead Reduction Ratio	GR		125:1		rotor/shaft
Output Shaft Thread Pitch	TP		0.2		mm/rev
Shuttle Step	L_{SS}		0.27		µm
Shuttle Travel	L_{ST}		3000	3300	µm
Shuttle Speed	V_S		1	400	µm/s
Direction Reversal Hysterisis	H_{DR}		100		µm
Microdrive Diameter	D		6.0		mm
Microdrive Length	L		24.0		mm
Microdrive Mass	M		1.5		g
Electrode Diameter	D_E			300	µm

Key to Exploded Views

Color	Part
red	cover
light tan	shuttle
gold	lead screw
grey/black/gold	motor assembly
light green	body
dark green	printed circuit board
light grey	Omnetics connector
blue	base
black line	electrode
dark grey	screws
purple	steel dowels

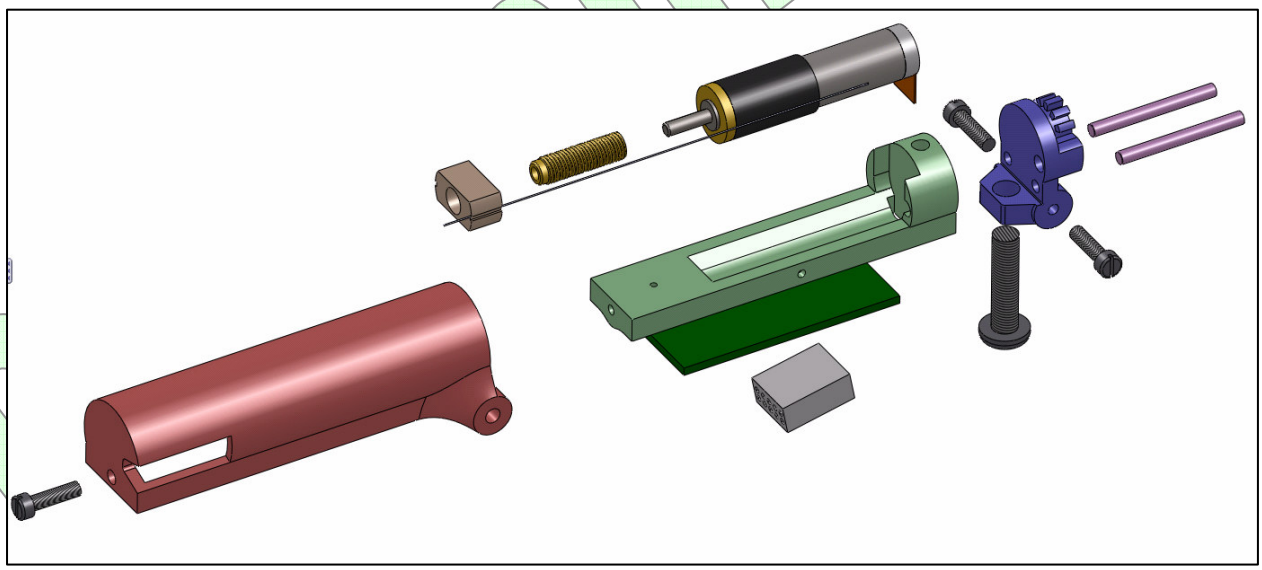


Figure 1 - Headstage Exploded View 1

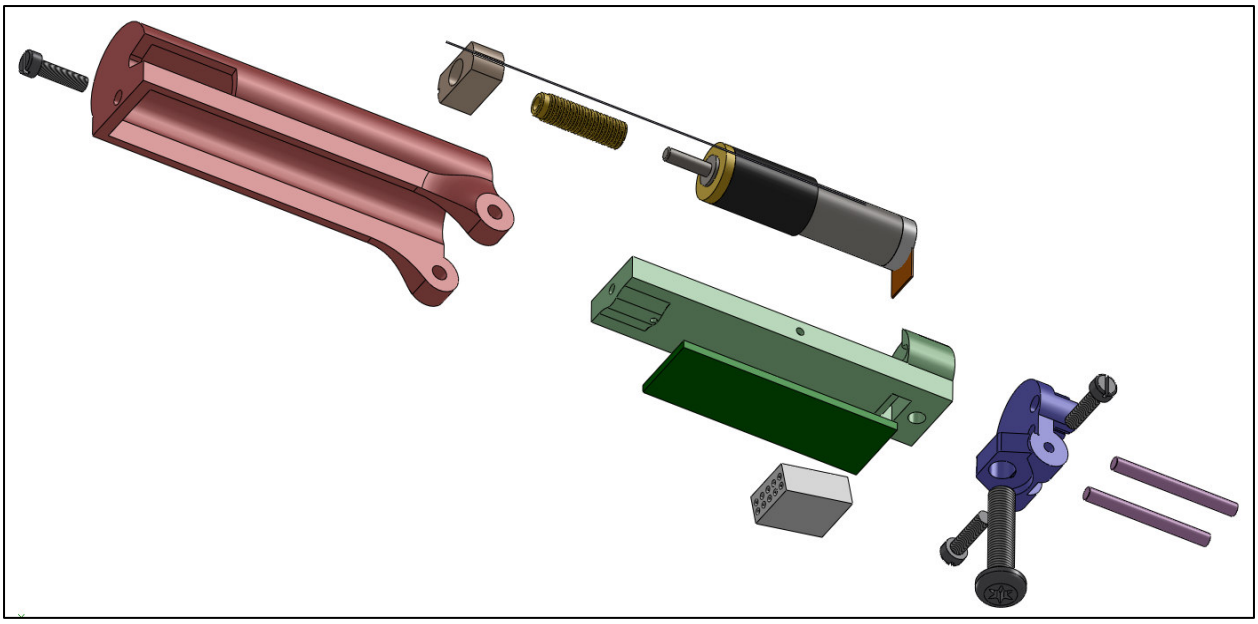


Figure 2 - Headstage Exploded View 2

Description

The ND1HS headstage translates the electrode(s) relative to the base when the motor turns.

The headstage incorporates a miniature motor and reducing gearbox mounted within a cylindrical body made of sturdy, lightweight, and chemically resistant plastic (See Fig.1). The gear head reduces 125 motor rotations to one output shaft rotation. The output shaft is a threaded lead screw, turning in a thread within a sliding shuttle. The shuttle can carry from one to four tungsten electrodes. The rotational movement of the lead screw transforms to linear movement of the shuttle at 0.2 mm per shaft revolution. The minimal motor rotation step is 60 degrees, corresponding to 0.27 µm of longitudinal movement of the electrode(s).

As with any precision mechanical device, there is hysteresis (backlash) when reversing direction as internal parts such as gear teeth move freely from one point of contact to another until output motion resumes. To achieve reproducible electrode placement, always move the drive in the same direction when approaching a location of interest. For example, if the main direction is forward, then to move electrodes back, first retract farther than the desired position by at least the amplitude of the hysteresis (H_{DR} = 100 µm) and then move forward to the desired position.

Electrodes are glued to the shuttle with epoxy. Electrical connection between electrodes and contact pads on the head stage is made using thin copper wire (40 AWG). It is recommended to embed the electrode wire connection and part of the wire close to the shuttle in epoxy to reduce stress on the solder joint.

During implantation the base is fixed in place with dental cement. The base, cover and shuttle are disposable. Several bases, covers, and shuttles are provided with each headstage or headstage kit so these items can be replaced if damaged or unsalvageable. The rest of the headstage is recovered by detaching the disposable components.

The headstage printed circuit board (PCB) provides an attachment point to an external tether cable via a fine pitch connector. Three pins of the connector attach to the motor. The remaining pins are accessible via PCB solder pads. Functions of these user accessible pads are defined by

the electronics of the attached tether, not by the headstage itself. The designations here derive from RP Metrix tethers. Looking at the connector from the tether, with body below, pin 1 is the leftmost pin of the row near the body. Pin 2 is in the row above.

I/O Information

ND1HS-NPD-10 (Omnetics Nanominiature Male) 10-Pin Interface Connector

Pin	Signal	Pad	Mark	Input/Output		Pin	Signal	Pad	Mark	Input/Output
1	Ground	G	G	--------		2	Reference1	R1	R	Output
3	Probe1	E1	1	Output		4	MotA	mA	A	Input
5	Probe2	E2	2	Output		6	MotB	mB	B	Input
7	Probe3	E3	3	Output		8	MotC	mC	C	Input
9	Probe4	E4	4	Output		10	Stimulus1	RS	S	Input

ND1HS-NPD-6 (Omnetics Nanominiature Male) 6-Pin Interface Connector

Pin	Signal	Pad	Mark	Input/Output		Pin	Signal	Pad	Mark	Input/Output
1	MotC	C	mC	Input		2	MotA	mA	A	Input
3	Reference1	R	R	Output		4	MotB	mB	B	Input
5	Probe1	E	E	Output		6	Ground	G	G	--------

Electrode Pad Information

Fig. 3 shows the top layer of the headstage printed circuit boards. The exploded views in this document show the B29 PCB and the corresponding 10-pin connector. All electrode, reference and stimulus connections are accessible on this layer. Fig. 3 shows a label for each PCB pad. These labels are in the **Pad** column of the **I/O Information** tables. On the PCB itself, there is room for a single character **Mark** near each pad.

For PCB B29, there are 4 pads for electrode circuits ('E1' to 'E4'), one pad for the reference circuit ('R1'), one pad for the stimulus circuit ('RS') and one pad for the ground circuit ('G'). A buffered tether attached to the connector provides electronic amplification for the electrode and reference circuits. On buffer version uses RS as a second reference, while another version uses RS as a stimulus input circuit. See the buffered tether datasheets for details. The other PCB options use a 6-pin connector. The C02 and C04 options have extra pads on the same circuits, in case repeated connections to electrodes damages one set of pads. The C03 and C04 options provide no reference pad(s).

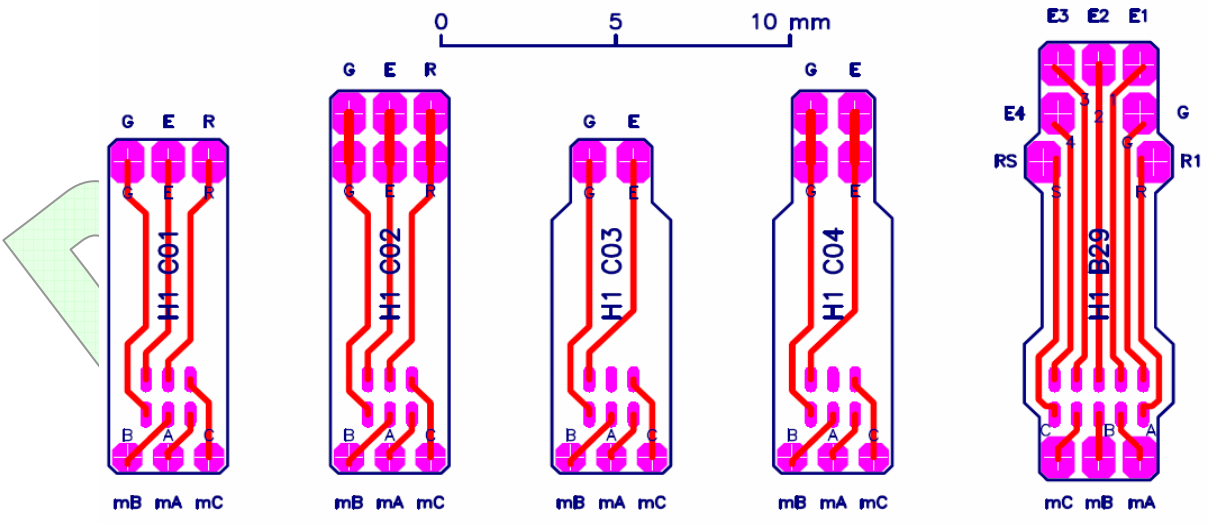


Figure 3 - Headstage PCB Options (Top Surface)

Kit Assembly Information (General Instructions) _____

Please read the assembly information thoroughly before beginning assembly of your microdrive.

Tapping

This process rewards patience. Lubrication with a small amount of water or alcohol is useful to remove debris when tapping the hole. Avoid oil because this will make cementing difficult. Occasionally reversing the tap is useful to clear out the debris when tapping. The plastic is translucent. Optically index match the plastic by wetting with water helps to help see where the tap is in the hole.

- If any resistance is felt reverse the tap to clear out debris.
- Lubricate well during tapping.

Solder flux

We use Kester #2331-ZX water based flux for all soldering (see **Third Party Supplies**). It performs excellently as a flux at a wide range of temperatures and is very easy to clean up.

Adhesive

We use a filled epoxy resin (see **Third Party Supplies**). The adhesive can be mixed by hand but the proportions are not 1:1. We found that using a dispensing gun and miniature mixers give consistently good results with minimal waste and guesswork.

The adhesive gives about 20 minutes of work time. After that it gets increasingly viscous until it sets. It is good practice to think the next step trough and practice with whatever clamps, third hands or weights you might need to hold the parts in place before actually cementing anything.

As with all epoxies the setting time is very temperature dependent so gently heating the parts can speed up the assembly time.

Note: Do not overheat the motor or plastic parts.

Mixing a batch of cement and cooling unused cement in a -4º C freezer for future use is sometimes useful. You will have to experiment and see how long you can keep usable epoxy at the particular temperature of your freezer.

Roughen the mating surfaces to improve the efficacy of the adhesive using a scalpel or sandpaper.

Motor

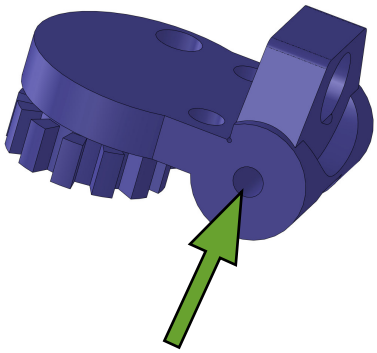
The motor and gearbox used by the ND1HS1 microdrive was chosen for its small size, low weight, large gear ratio, and low voltage drive signals. The motor was designed for less mechanically stressful applications. It is easily damaged by handling or improper use. The motor is very delicate. Be very careful when handling during the assembly process. Please pay attention to the following:

- Do not let liquids get into the motor.
- Do not pull the motor (metal cylinder) from the gearbox (grey plastic).
- Do not pull the brass flange from the gearbox.
- Do not pull the shaft (thin steel rod) from the brass flange.

Kit Assembly Information (Step by Step Instructions) _____

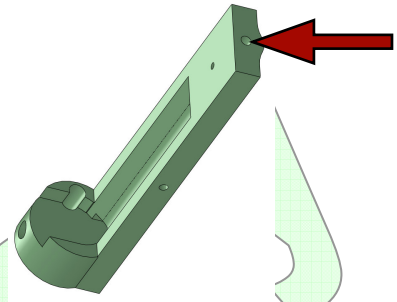
1. Tap 000-120 holes in the base.

Tap two 000-120 tapped holes, one in either side of the base. Do this in one pass. The tap is much longer than the part that needs to be tapped. This is a through-all tap.



2. Tap a 000-120 hole in the top of the body.

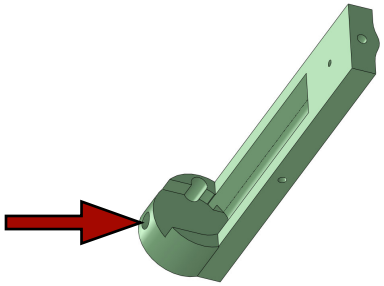
This hole is tapped in the top of the microdrive body using the same 000-120 tap as the base. The hole is not open at the bottom. Occasionally reverse the tap to clear out the debris. Do not tap too deep, otherwise the plastic will crack or the threads will be stripped.



Note: Use caution so as not to tap too deep.

3. Tap a 0-80 hole in the base of the body.

Tap a 0-80 hole near the bottom of the body. This is a through-all tap.



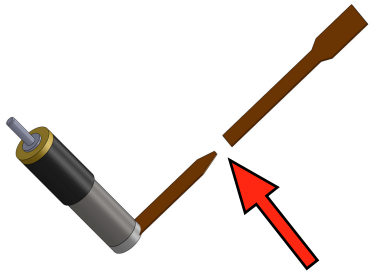
4. Clean plastic parts before assembly.

Before cementing parts in place be sure that plastic parts are clean.

Plastic parts will be attacked by long term exposure to certain solvents. We typically clean the plastic parts in an ultrasonic cleaner using ethanol for about a minute. This seems to have no adverse effect. Blow the parts dry with compressed air.

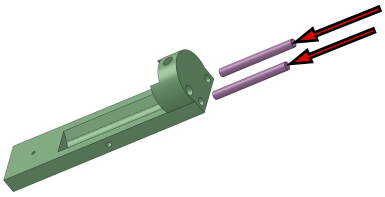
5. Snip wide connector off of flex cable.

Snip the wider connector pads from the motor flex cable about 10 mm from the motor body. Cut a point in the cable for easier insertion into the slot. This allows the cable to slide into the slot near the bottom of the body. A final cut and connections to the flex cable traces will be made in a later step.



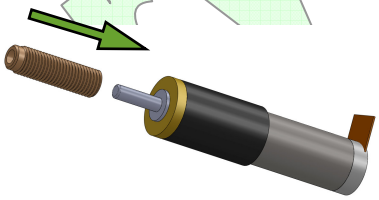
6. Push steel pins into microdrive body.

There are two holes in the body that accept steel pins. Gently push the two steel pins partially into the body holes. The pins should protrude 1 mm form the bottom of the body. The manufacturing process may leave a waxy support residue in the holes. Remove any support residue squeezed out from the drain holes.



7. Cement lead screw to motor shaft.

Note: Cementing the lead screw is an irreversible step.



First, check that the lead screw fits the shuttle well by screwing it back and forth through the shuttle. Now is the time to remove any burrs or dirt.

Carefully clean the motor shaft using an alcohol dampened cotton swab. Do not let liquid into the motor.

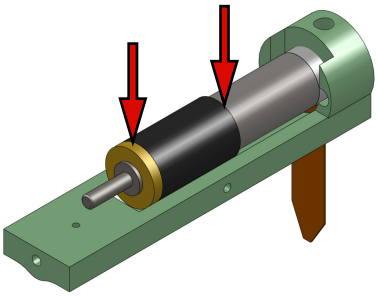
Clean the lead screw by immersing it in alcohol and blow drying it. Using a small weighing boat filled with alcohol in an ultrasonic bath is a good way to do this.

Note that the lead screw has a small guide step on one end. This is to facilitate insertion of a shuttle. The end with the guide step is the end *away* from the motor when assembled.

Mix a small amount of adhesive using the correct mixing ratio. Put a tiny amount of adhesive in the motor side of the lead screw. Apply a tiny amount of adhesive to the motor shaft. Gently and slowly insert the lead screw onto the motor shaft. Rotate the lead screw to spread the adhesive. While rotating, quickly clean up any adhesive that accumulates when the lead screw is sliding towards the motor. A small wood splinter is good for this.

Make sure that no epoxy will cement the shaft to the brass gearbox flange, thus preventing rotation.

8. Cement motor into microdrive body.



This attaches the motor to the microdrive body. When cementing the motor do not use excessive amounts of cement as this serves no purpose and simply increases the drive weight.

Add cement where motor parts join to prevent the motor from coming apart (see red arrows).

9. Attach Omnetics connector to circuit board.

Solder the connector to the circuit board with the correct orientation. The best way to do this is very slowly and deliberately. For us, 95% of this step is in the setup and 5% is the actual soldering.

Before proceeding, find the correct temperature setting for your heat gun for melting the solder you use.

First, coat all of the pads with solder. Do the same for the connector leads. Put an ample amount of soldering flux on the pads. Use a "third hand" holder to hold the connector in the correct position. Heat the pads and leads with a heat gun to simultaneously make the solder joints.

Alternatively, the soldering can be done pin by pin. This can be difficult because of the tight spacing. This will be easier for those using a 6-pin connector since there will only be 3 contacts in each row of the connector.

Pay attention to the following:

- Make sure the connector is facing in the correct direction. The tether will connect on the far side of the PCB – away from the base.
- Make sure the connector is at about a 20º to 30º angle to the circuit board. This will allow easy engagement of the tether to the microdrive.

10. Solder wires through circuit board vias.

Solder wires (about 40 AWG) through the vias near the motor end of the circuit board using regular solder. (Pads marked A, B and C.) Be sure to mechanically fasten the wires because these joints will probably melt when soldering the wires to the motor.

11. Attach circuit board to body.

Attach the circuit board to the body using epoxy.

12. Wire motor to PCB.

Carefully snip the flex cable close to the body leaving enough flex cable to allow exposing the copper traces for soldering. Carefully scratch the upper layer of the flex cable to expose the copper. Tin the exposed copper. Solder the wires attached to the PCB pads to these exposed traces.

13. Cover any bare wires.

Cover the exposed motor to PCB wires and the associated PCB pads with nail polish or PlastiDip to prevent corrosion and / or short circuits by exposure to saline. PlastiDip remains elastic, which facilitates removal if repairs are needed.

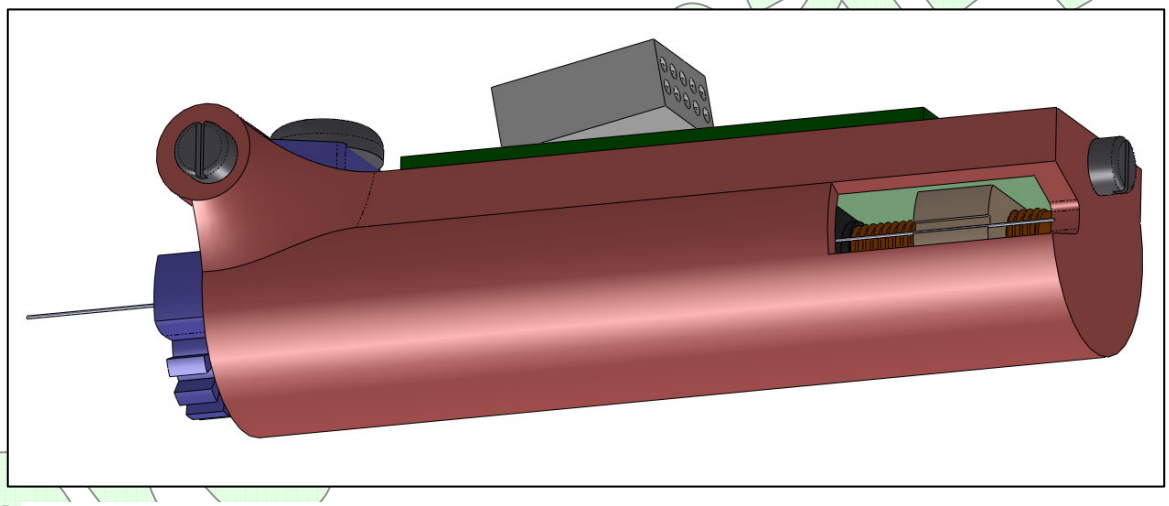


Figure 4 - Assembled Microdrive (adhesive not shown)