RP Metrix

Single Microdrive Neural Recording System Overview	ND1SYS

Lightweight Motorized System for Awake Animal Neural Recording

- **Single motor microdrive**
- **1 to 4 microelectrode circuits**
- **0 to 2 reference or stimulus circuits**
- **~1.1 gram total microdrive mass**

Figure 1 - ND1HS-1C5

Components (Partial List)

Part Number	Description
SMDK1-pcb	ND1HS1 kit, with motor, unassembled (-pcb designates circuit board and connector)
SMDK3	ND1HS1 consumables
SMDT1	Tool kit
ND1PA-1	4-channel differential preamplifier
ND1BA-1	4-channel op-amp buffered tether cable
ND1TC-1	4-channel unbuffered tether cable
ND1PA-1X	2-channel differential preamplifier
ND1BAJ-1X	1-channel JFET buffered tether cable
ND1TC-1X	1-channel unbuffered tether cable
ND1SAF-1	Shuttle Assembly Fixture
ND1MEC-1	Microelectrode Capillary
ND1MC2+	1-drive motor controller, MC2 plus standalone capability
MC2_A2	Adapter for MC2 to ND1 tether, PCB, motor leads only.
MC2_A3	Adapter for 4-electrode recording systems (MC2, DB15, BNC, jacks)
ND1RCS-1	Adapter, TDT AC16 to ND1PA-1X
ND1AC16	ND1 Mock AC16
ND1BAJ-AC16	JFet Buffered Tether Cable, reterminated for TDT AC16

Description _____

An example 1-motor microelectrode system consists of the components listed below (see Fig. 2). This example shows one of many possible configurations. Some variations will be described later in this document.

- The microdrive. (see Fig 1) The microdrive is implanted on the animal. It has 1 micromotor. The motor moves a shuttle with submicron resolution. The shuttle can carry 1 to 4 metal electrodes. A smaller connector is used when fewer electrodes are needed. The connector carries electrode signal(s), 3 motor signals, ground, and 0, 1, or 2 reference or stimulus signals.

- A signal buffer and flexible cable. This is attached to the microdrive during recording. The signal buffer is the first stage of signal amplification and processing. The buffer has unity voltage gain. A buffer is used for each electrode, and for each (optional) reference signal.

- A multi-channel differential preamplifier. This is the next stage of signal amplification. Each differential amplifier has voltage gain and a band pass from sub Hz to over 20 KHz. Each amplifier scales up the difference between its electrode signal and either ground or one of several references.

- The rotational commutator. The multi-channel preamplifier hangs from the rotational commutator in this example, so that the cable is allowed to rotate freely and avoid twisting.

- The motor adapter. The rotational commutator is connected by standard cable to the motor adapter. The adapter routes signal channels to the data acquisition system. It also provides the connections for the amplifier/buffer power supply and microdrive motor controller. In some adapters, the microdrive motor controller can be completely disconnected from the commutator cable to reduce noise pick up.

- The microdrive motor controller, supporting the motor in the headstage. This may be used in a standalone mode, or be connected via USB to a host computer.

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Figure 2 - Neural Implant System

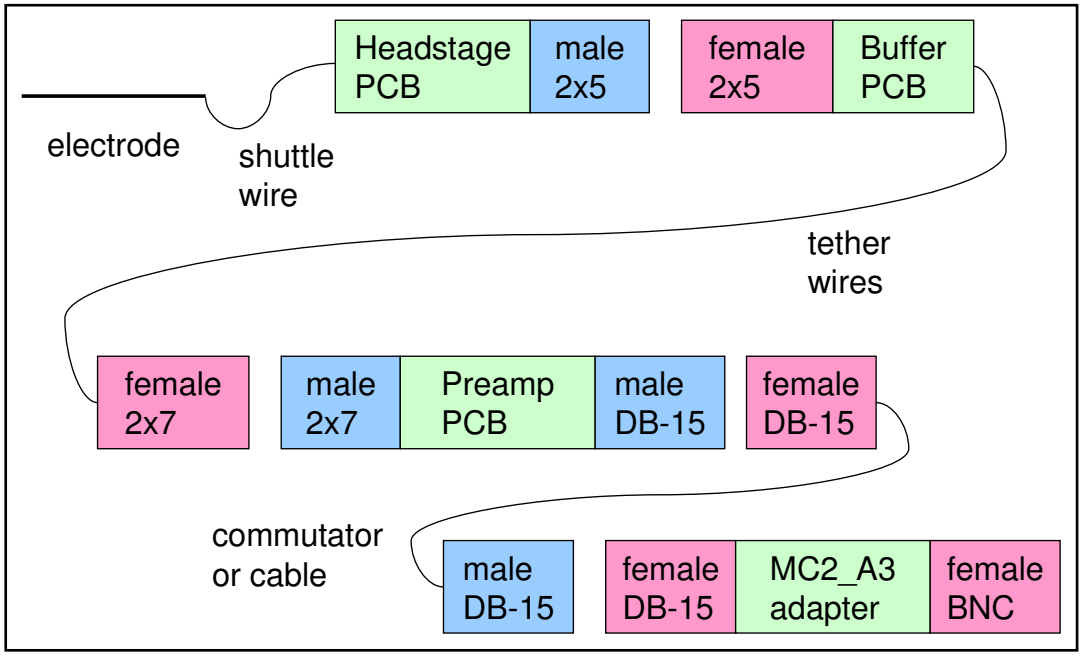

Figure 3 - Buffer/Preamp Signal Chain

Electrode Signal Chain

Fig 3 shows some details of a typical electrode signal chain. The printed circuit boards (PCBs) in this diagram have these functions:

- Headstage PCB – Electrical paths to tether connector.
- Buffer PCB – Buffer transistor or op amp channel per electrode. Unity voltage gain is typical.
- Preamp PCB – Differential amplifiers, voltage gain times difference between buffered electrode and a (shared) reference.

The ND1PA1X preamp shares its positive supply with JFet transistors on the buffer PCB, one per electrode or reference signal. The ND1PA1 preamp provides onboard regulators to supply multi-channel voltage follower op amps on the companion buffer PCB, one channel per electrode or reference signal. Note that in Fig 4 and 5, the negative side of preamp differential amplifiers are fed with similar buffered signals to those feeding the positive side.

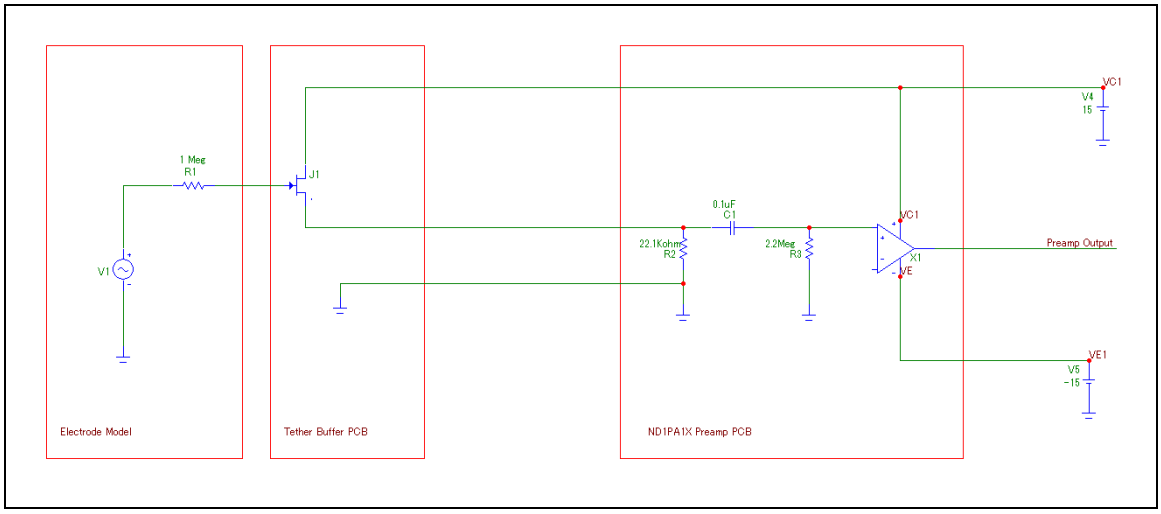

Figure 4 - JFet Buffer Chain Circuit Elements

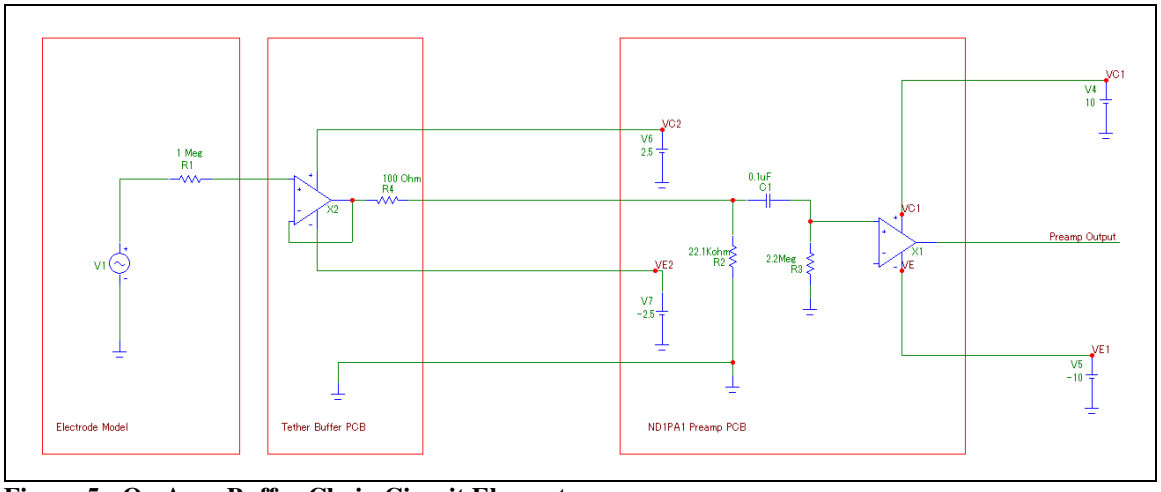

Figure 5 - Op Amp Buffer Chain Circuit Elements

Variations

Head-stage connector

Mounted on the head-stage is a connector (Omnetics Nanominiature, male) which potentially carries signal circuits for the motor, electrodes, ground, reference, and stimulus. The head-stage mass is slightly reduced if only a subset of these circuits is needed, so a smaller connector is used when requested. The variation shown in Fig 1 is a model ND1HS-1C5 microdrive. This model uses only 5 circuits in the connector. There are always 3 motor signals. The remaining 2 circuits are for ground and one electrode. Two solder pads are visible in the picture for these latter circuits. The motor connections are covered with epoxy and are not visible. Fig 2 shows a 2x5 male connector, this is a 10-pin connector for a model ND1HS-1C10 microdrive or microdrive kit SMDK1-B29.

Fig 6 shows the top surface of some of the head-stage PCB options. The “C03” PCB was used for the microdrive in Fig 1. Note the two solder pads marked “G” and ”E” at the top. These are the exposed ground and electrode pads visible in Fig 1. The motor circuit pads “A”, “B”, and “C” are covered with epoxy after microdrive assembly.

The “C04” PCB just adds more pads in case repeated soldering damages one set as the microdrive is reused.

The model ND1HS-1C6 microdrive uses a “C01” or “C02” PCB, which adds solder pad(s) for a reference or stimulus signal. These pads are marked “R” in Fig 6.

The model ND1HS-1C10 microdrive uses a “B29” PCB. This has pads for 4 electrodes, ground, and 2 other reference or stimulus signals.

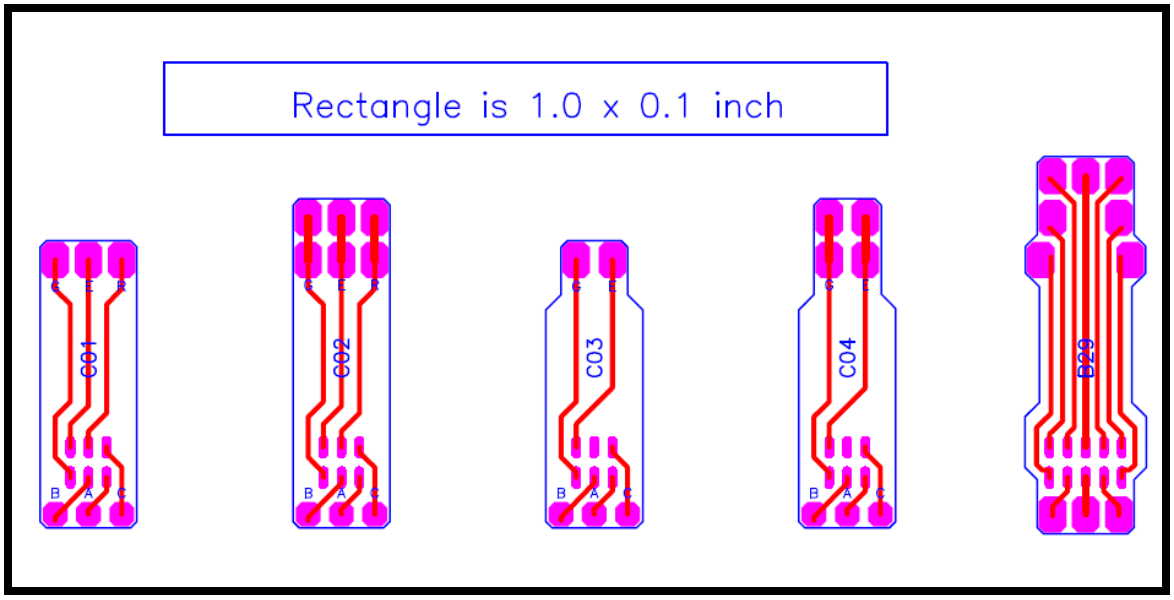

Figure 6 - Headstage PCB Options

Buffered Tether

The head-stage connector mates with a female Omnetics Nanominiature connector mounted on a buffer PCB. Away from the head-stage, a tether cable attaches to the buffer PCB. Since circuits on the head-stage are routed via the connectors to electronics on the buffer PCB, the buffer PCB defines the use of the exposed pads. Electrode or reference signals connect to buffer inputs. Ground is carried through from the tether. Stimulus and motor signals are just routed through the buffer PCB.

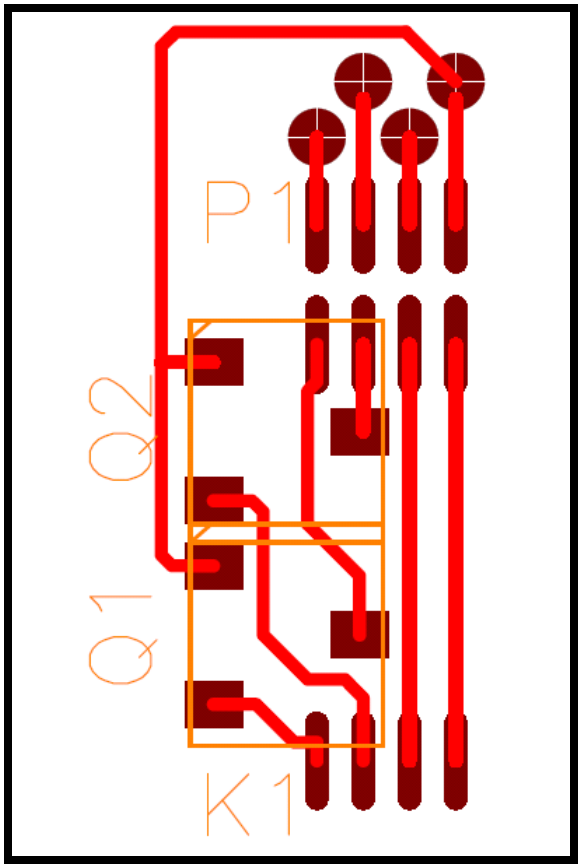

Figure 4 - JFET Buffer PCB (Top Layer)

Fig 7 shows the top layer of the PCB for a model ND1BAJ-1X tether. Near "P1" are the 8 pads for the connector mating to the head-stage. This 6-pin connector mounts on the top surface, and uses 6 of the 8 pads. (Two pads carry buffer power and are not needed on the head-stage.)

Near "K1" are half of the the pads for the tether cable. The other cable pads are on the bottom side of the board.

JFET transistor "Q1" buffers one signal from the head-stage. The head-stage connects to the transistor input, and the transistor output connects to a wire in the tether.

The Q1 and Q2 inputs are typically an electrode and a reference signal, to provide the best differential matching before sending the transistor outputs up the cable.

Differential Preamp

Fig 8 shows images of the ND1PA1X 2-Electrode preamp (front and back), and the ND1PA1 4-Electrode preamp (front only).

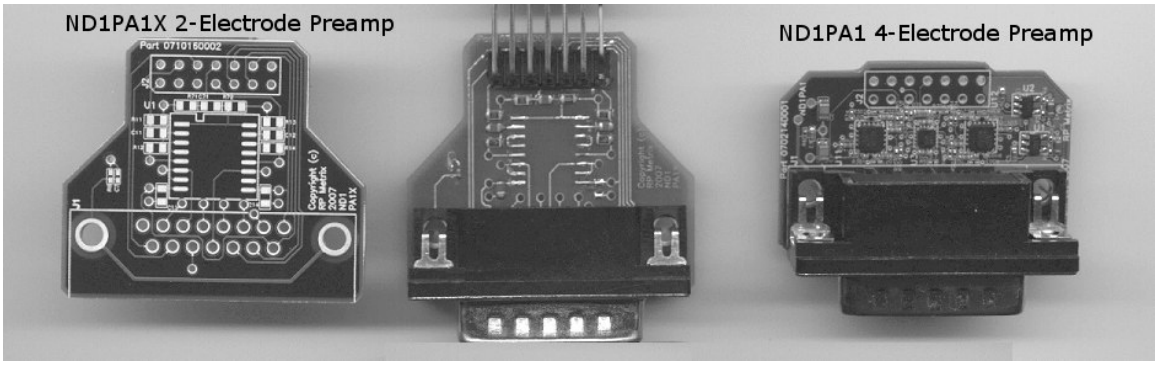

Figure 5 - Preamplifier Images

These preamplifiers shown in Figure 5 share a common 15-pin commutator connector. This connector is pin compatible with the MC2_A3 adapter J2 connector. Pin 1 is near "J1".

ND1PA1-J1 (DB-15 Male) 15-Pin Commutator Interface Connector

Pin #	Signal	ND1PA1 Input/Output	ND1PA1-X Input/Output	Notes
1	Signal Ground	--------	--------	
2	RefOut1	Output	No Connect	Note [1]
3	SigOut1	Output	Output	
4	SigOut3	Output	No Connect	
5	Blank Preamp	Input	No Connect	Note [2]
6	Stim3	Input	No Connect	Note [3]
7	Stim2	Input	No Connect	
8	Vpos <= 15V	Input	Input	Note [4]
9	Motor2	Input	Input	Note [5]
10	Stim1	Input	Input	
11	SigOut2	Output	No Connect	
12	SigOut4	Output	Output	
13	Motor1	Input	Input	
14	Motor3	Input	Input	
15	Vneg >= -15V	Input	Input	

[1] Differential preamp channels are configured to use ground, reference input, etc. as the negative input. The reference may be monitored via this output pin.
[2] The motor controller provides a logic blanking signal which the preamp may use to squelch motor noise.
[3] Stimulus signals are direct wired to the tether connector, if connected at all.
[4] Typical preamp supply is +/- 12V.
[5] Motor signals are direct wired to tether connector.

On the tether side of these preamplifiers is a common 2x7 14-pin connector.
Pin 1 is near "J2". Pin 2 is opposite pin 1.

ND1PA1-J2 (14-pin 0.100" 2x7 male) 14-Pin Tether Connector

Pin #	Signal	ND1PA1 Input/Output	ND1PA1-X Input/Output	Notes
1	SigIn1	Input	Input	
3	SigIn2	Input	No Connect	
5	SigIn3	Input	No Connect	
7	SigIn4	Input	Input	
9	Motor1	Output	Output	
11	Vneg	Vneg Output	BufNeg Output	Note [6],[7]
13	Stim3	Output	No Connect	
2	Signal Ground	--------	--------	
4	Motor2	Output	Output	
6	Stim1	Output	Output	
8	RefIn1	Input	Input	
10	Motor3	Output	Output	
12	Vpos	Vpos Output	BufPos Output	
14	Stim2	Output	No Connect	

Caution:

Note that the preamps and buffered tethers, although they use common connectors, are not interchangeable.

The ND1PA1X preamp feeds the Vpos supply through to the buffer, intended to drive the high side of a JFet channel (See Figure 4). The Vpos voltage may be up to 15 volts.

The ND1PA1 preamp provides regulated +/- 2.5 Volts to an op-amp buffer. (See Figure 5.)

The higher voltage from the ND1PA1X will damage an op-amp buffer intended to mate to the ND1PA1 preamp.

[6] ND1PA1-X direct wires Vpos and Vneg to tether.
[7] ND1PA1 provides onboard regulators for tether buffers, generating +/- 2.5V.