



Microdrive Motor Controller MC1	ND3MC1
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Multi-channel Microdrive Motor Controller for Miniature Microdrive Neural Recording System

- 3 motor drive channels
- USB control interface
- Manual keypad interface
- Field upgradeable firmware
- Automatic control of ND3PIF Pre-amplifier Interface motor operation isolation circuits
- Microsoft Windows (R) Win32 driver and control program

- Single 5 VDC supply available from power adapter or ND3PIF
- Internal current limited bipolar motor drivers
- Auxiliary I/O option



Ordering Information

Configuration	Part Number
Multi-channel Motor Controller MC1	ND3MC1-1
Replacement external 5 VDC adapter	ND3PDC-1

Absolute Maximum Ratings

Characteristic	Symbol	Min	Typ	Max	Unit
Input DC Supply Voltage	V_{DC}	-0.3	5.0	5.5	V
Input DC Supply Isolation to Ground	V_{SISO}	700			V
Motor Circuit Current	I_{MOT}	-500		500	mA
Motor Circuit Voltage (Monitor Input)	V_{MOT}	-10.3		10	V
Output Short-Circuit to Ground Duration	t_{SC}			∞	sec
Operating Temperature	T_A	0		70	°C
Storage Temperature	T_S	-40		85	°C
USB VBus ¹	V_{VBUS}	-0.3	5.0	5.5	V
USB D+, D-	V_{USBD}	-0.5		5.25	V
Ext Digital I/O Input Voltage	V_{DIO}	-0.5		6.5	V
Ext Digital I/O Output Current ²	I_{DIO}	-50		11	mA
Ext Digital I/O Clamp Current ($V_{DIO} < 0$)	I_{DIOK}	-50			mA

¹ Internally disconnected. MC1 current load exceeds USB specifications for bus powered devices.
² Pulled up to 3.3V with 300 ohms.

Specifications

At $T_A = +25^\circ\text{C}$, $V_{DC} = 5\text{V}$, unless otherwise noted.

Characteristic	Symbol	Min	Typ	Max	Unit
Input DC Supply Voltage (in operation)	V_{DC}	4.5	5.0	5.5	V
Operating Supply Current	I_S		750	1500	mA
Motor Drive Signal (Common)					
Output Voltage Magnitude	V_{Com}	0.0	3.023	4.922	V
Output Current Limit	I_{Com}	0.0	148	248	mA
Motor Drive Signal (Individual)					
Output Voltage Magnitude	V_{Ind}	0.0	3.023	4.922	V
Output Current Limit	I_{Ind}	0.0	100	248	mA
Motor Drive Sinusoidal Frequency	F_{Mot}	4.16	4.16	67.66	Hz
Motor Step Rate	F_{Step}	25	25	406	step/sec
Step Counter Range		-32768		32767	step
Ext Digital High Level Output Voltage	V_{OH}		3.3		V
Ext Digital Low Level Output Voltage	V_{OL}		0.4		V
Ext Digital High Level Input Voltage	V_{IH}	2.0			V
Ext Digital Low Level Input Voltage	V_{IL}			0.8	V

Description

The ND3MC1 Microdrive Motor Controller is a table top module that connects to the motors within an ND3HS1 Three Drive Neural Headstage, either directly or via an ND3PIF 12-Channel Pre-amplifier Interface. The MC1 also connects to a DC power supply, optionally connects via USB to a user supplied host computer, and optionally connects to a user supplied auxiliary digital I/O device.

A 12-key manual control keypad is mounted on the top surface of the MC1, along with 3 red-green LEDs that indicate motor activity and direction.

The rear panel of the MC1 has a DC power jack and on-off toggle switch for the ND3PDC-1 5V DC adapter included with the MC1.

The rear panel has a male DB-25 connector wired for connection to an ND3PIF-1 12-Channel Pre-amplifier Interface. This connector outputs motor control and motor activity signals, and optionally inputs 5C DC power for the MC1.

The rear panel has a USB 2.0 Type B jack for use with the user supplied host computer. A 5-meter USB 2.0 Type A to Type B cable is supplied with the MC1. A CDROM supplied with the MC1 contains software for installation in a user supplied PC running Microsoft Windows 2000 (R), Windows XP (R), or a compatible operating system. USB driver and user application programs are included.

The rear panel also has a 2-pin jack for use with an auxiliary digital I/O device. The motor activity signal is output via this jack. Firmware support for digital input is not implemented.

The MC1 is normally used in at least two configurations: **Head stage assembly** and **head stage operation**.

In the **head stage assembly** configuration, manual control of one or more motors is useful to install and position shuttles and complete electrode attachment and installation. In this situation, the MC1 needs only the local power adapter and a simple cable to the motor circuits of the headstage. The MC1 keypad functions can be used to step each motor forward or backward, or run a motor continuously until manually stopped. The operator typically observes the motor, shuttle, and electrodes visually during these procedures.

In the **head stage operation** configuration, computer control or manual control of the motors via the ND3HS1 is expected, so that electrode positioning and neural data collection can be efficiently interleaved. The MCPlayer application program included with the MC1 permits an operator to control motor position, direction, and speed via a USB connection to a user supplied PC. The MC1 sends motor control signals via the ND3PIF to the headstage. The MC1 sends a motor activity control signal to the ND3PIF; causing the ND3PIF to release the motor isolation relays and to clamp the electrode signal buffers to ground. The MC1 can obtain DC power from the ND3PIF so the MC1 DC power adapter is not required.

During normal processing of neural signals, the preamplifier connected to the ND3PIF supplies 12 amplified microelectrode signals. These ND3PIF inputs are direct wired to outputs on the ND3PIF rear panel. These inputs are also wired to four analog multiplexers controlled by four ND3PIF front panel selector knobs. The multiplexer outputs pass through unity gain buffers to 4 outputs on the ND3PIF rear panel. The direct wired outputs typically drive inputs of a user supplied data acquisition system. The multiplexer outputs typically drive inputs of a user supplied display device, such as an oscilloscope.

During operation of the motor controller, large disturbances can be induced in the neural signal channels. This problem is mitigated in two ways. (1) The ND3PIF front panel motor enable button toggles internal relays on and off, so that the motor controller circuits (including ground) are only connected to the preamplifier when needed to operate the motors in the headstage. (2) When motor control is enabled, the monitor multiplexers temporarily select a grounded input, preventing saturation of the monitor device. Current versions of the ND3PIF use the motor activity signal from the MC1 to automatically operate the motor enable relays and multiplexer clamp functions, so the ND3PIF front panel motor enable button is not needed.

I/O Information

ND3MC1-J1 (DB-25 Male) 25-Pin Motor Interface Connector

Pin #	Signal	Input/Output	Pin #	Signal	Input/Output
1	Motor Ground	Output	14	Ground	-----
2	Ext 5 VDC	Input	15	Ext 5 VDC	Input
3	Ext 5 VDC	Input	16	Motor A (1) ³	Output
4	Motor Com	Output	17	Motor Ground	Output
5	Ground	-----	18	Ground	-----
6	Ext Digital I/O	Bidirectional	19	No Connect	
7	No Connect		20	Motor B (2)	Output
8	Motor Com	Output	21	Motor Ground	Output
9	Motor Ground	Output	22	Ser Clk Pos ⁴	Output
10	Ser Clk Neg ⁵	Output	23	Ser Data Pos ⁶	Output
11	Ser Data Neg ⁷	Output	24	Motor C (3)	Output
12	Motor Com	Output	25	Motor Ground	Output
13	Motor Ground	Output			

ND3MC1-J2 (5.8 mm Jack⁸) 2-Pin DC Power Jack Interface Connector

Pin #	Signal	Input/Output	Pin #	Signal	Input/Output
1 (center)	V _{DC} Supply	Input	2 (barrel)	V _{DC} Return (Gnd)	Input

ND3MC1-J3 (USB Type B) 4-Pin USB Host Interface Connector

Pin #	Signal	Input/Output	Pin #	Signal	Input/Output
1	VBUS	Input	3	D+	Input
2	D-	Input	4	Ground	-----

ND3MC1-J4 (3.5 mm Jack) 2-Pin Aux Interface Connector

Pin #	Signal	Input/Output	Pin #	Signal	Input/Output
1 (center)	Ext Digital I/O	Bidirectional	2 (barrel)	Ground	-----

³ Motor A, B, and C correspond to MC1 channels 1, 2, and 3, respectively.

⁴ Reserved for future use

⁵ Reserved for future use

⁶ Reserved for future use

⁷ Reserved for future use

⁸ CUI, Inc., PJ-005B

Manual Keypad Operation

The 12-key manual keypad on top of the MC1 module has the layout shown here.

1↑ 2↑ 3↑

The top two rows of keys are **start** keys used to select and start continuous motor motion.

The key marked "1↑" starts motor 1 in the extract direction (increasing step count). The LED above the left key column glows green.

1↓ 2↓ 3↓

The **"STOP"** key must be pressed to stop the motor. The LED turns off.

* ↓ STOP * ↑

The key marked "1↓" starts motor 1 in the insert direction (decreasing step count). The left LED glows red.

It is not required to stop in order to change direction.

1* 2* 3*

Motion starts at the slowest speed. If the start key is held, the speed will double each second until the maximum speed is reached.

The keys in the bottom row are **macro step** keys. Each press of "1*" causes motor 1 to move a fixed number of steps, called a **macro step**. Upon power up, the default MC1 macro step is 1 motor step (1/6 of one rotation). The corresponding electrode motion depends on motor gearing and shaft thread pitch. On the ND3HS1 with a gear down ratio of 1:125, the default single step represents 1/750 of a shaft turn, and electrode motion of 0.267 microns.

A host computer attached to the USB interface can change the number of steps per macro step to any number in the range 1 to 65535. The USB connection can then be removed, but power to the MC1 must be maintained to keep the macro step setting.

The macro step direction is recalled from the most recent motion, or from the most recent **direction** key. The "*"↑" direction key sets the direction to extract (increasing step count) and all LEDs to green. The "*"↓" direction key sets the direction to insert (decreasing step count) and all LEDs to red. The motors will stop when a direction key is pressed.

Note that on power up, the LEDs are all turned on to green until the firmware initialization completes. At that point, LED 1 is red, LED 2 is off, and LED 3 is green. No motor motion will start until a key is pressed or a host command occurs. Upon that event, the LEDs will indicate motor activity or a change of direction.

Note: Motor A, B, and C correspond to MC1 channels 1, 2, and 3, respectively.

Software Installation

Included with the MC1 is a software installation CDROM. Check the RP Metrix web site (www.rpmetrix.com) for information about the latest software, which may be newer than the version described in this document. The top-level folder "RP Metrix" contains these items:

File Name	Description
RedPill.inf	Windows USB driver information
RedPill.sys	Windows USB driver
MCPlayer.exe	User program to operate the MC1 motor controller
LoadBoard.exe	Maintenance program to upgrade firmware
fw.iic	Backup copy of MC1 firmware (this name may depend on the version)

This software is designed for use on a PC running Windows (R) 2000 or Windows XP. This software can not be used with Windows 98, Me, NT or earlier versions of Windows. Only Administrators can install the USB driver. After that, any user can operate the motor controller with MCPlayer.exe.

When the MC1 is first connected to a PC USB port, the operating system will detect a new unrecognized device. Depending on the type of Windows (R) operating system, you will be prompted by the Found New Hardware Wizard to install the new driver. The steps listed below are for Windows 2000. Follow the wizard prompts to:

- Search for a suitable driver for my device.
- Specify a location.
- Browse to the CDROM (or a copy), browse into the RP Metrix folder, then select RedPill.inf and click Open.
- Confirm that windows found RedPill.inf in the proper folder and click Next.
- If a Digital Signature Not Found window pops up for "RP Metrix MC1 USB device", click Yes to continue the installation.
- Close the wizard by clicking Finish.

You should now be able to run the application programs.

Upgrading Firmware with LoadBoard

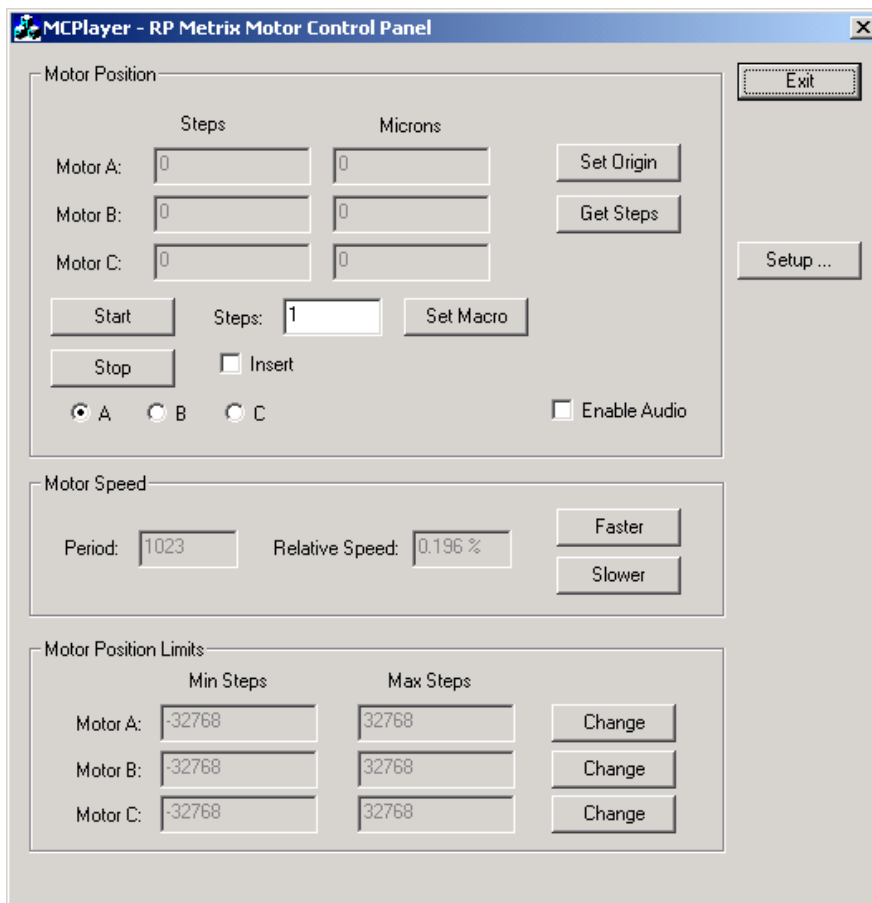
After the USB driver is installed, the LoadBoard.exe program can be used upgrade the firmware in the MC1, if necessary. This program can also make the MC1 unusable, so use this program only as directed by your technical support representative.

Controlling Motors with MCPlayer

After the USB driver is installed, the MCPlayer.exe program can be used to control motors via the MC1. MCPlayer monitors motor activity initiated by the MC1 keypad. It can also initiate motor activity from the operator's computer.

The MC1 is polled at one second intervals to check for changes in the motor position. Any changes cause the display to update. If audio is enabled, the PC will beep. The position is displayed in units of steps (1/6 of a motor rotation), and in microns. The step to micron scale factor defaults to the ND3HS1 scaling. This can be changed with the "Setup..." button.

The "Get Steps" button reads the motor position counters in the MC1 immediately. These counters can be reset zero with the "Set Origin" button. This is the power up state of the MC1.



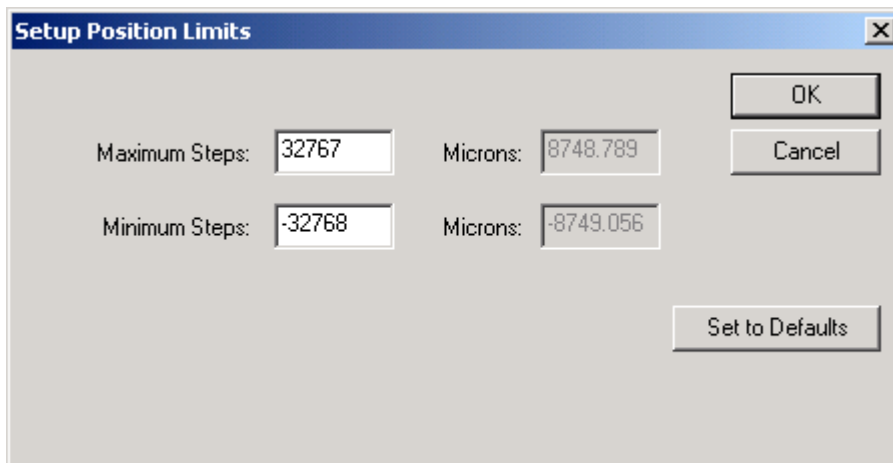
The program moves a motor in units of **macro steps**. The start up macro step value is one motor step, but can be changed by entering a new value and clicking "Set Macro". The new value is written to the MC1, and will affect the number of steps taken when a macro step key is pressed on the keypad.

The "Start" button causes one macro step to begin for the selected motor. The motor is selected with the "A", "B", and "C" radio buttons. (Corresponding to motor 1, 2, and 3 respectively on the MC1 keypad.)

Motor direction is determined with the "Insert" check box. If unchecked, the direction is extract (increasing step count). If checked, the direction is insert (decreasing step count).

Motor speed can be adjusted by clicking "Faster" or "Slower". Only these MCPlayer buttons change the motor speed, but the MC1 keypad will still affect motor speed as described for manual operation. The maximum speed is limited in part by the MC1 firmware, so "Relative Speed" calculation is not accurate at high values.

MCPlayer will not allow itself to change the position beyond the limits shown in the "Motor Position Limits" group. There is no such constraint on manual keypad operation, since the operator is expected to be observing the headstage. These limits can be adjusted via the "Change" buttons, one for each motor. The units shown on the main display are basic steps, but the pop up box for changing the limits will also show them in units of microns, based on the current scale factor. The limit values are not currently saved. The pop up dialog to change the position limits for a motor is shown here:



Note that the current firmware uses a signed 16-bit counter to keep track of a motor position. The MC1 adds and subtracts steps from this counter as it moves a motor. If a motor rotates past the limits of the counter, it will wrap to the other end of the range and continue changing from there. The MC1 will not try to prevent a counter wrap.

MCPlayer can configure selected settings within the MC1 whenever the program is started. These options are controlled via the "Setup..." button, which pops up the dialog box shown here:

The screenshot shows a software dialog box titled "Desired Settings" with a close button (X) in the top right corner. The dialog is organized into several sections:

- Device ID:** A text field containing "RP Metrix, MC1, Nov 22 2005 14:35:37 ID:1001". To its right are "OK" and "Cancel" buttons.
- Microns per step:** A text field containing "0.267". To its right is a "Set to Defaults" button.
- Waveform Magnitude:** A section with two columns: "Desired Settings" and "Actual Settings". Each column has two rows: "Common" and "Individual". Each row has a text field and a "3.023 Volts" button. Below this section is a checked checkbox "Set at program start" and a "Set Now" button.
- Motor Current Limits:** A section with a warning "(WARNING: High values may permit motor damage)". It has two columns: "Desired Settings" and "Actual Settings". Each column has two rows: "Common" and "Individual". Each row has a text field and a voltage/amp button (e.g., "0.148 Amps"). Below this section is a checked checkbox "Set at program start" and a "Set Now" button.
- Support log:** A section with an unchecked checkbox "Enable" and a text field "File name: MCPlayerLog.txt".

For information, the Setup dialog shows the Device ID, which is read from the MC1. The identification includes the manufacturer, device name, firmware version, and serial number.

The scaling in microns from one motor step to the corresponding electrode motion can be changed via this screen.

The waveforms generated by the MC1 to activate the motors can also be changed here. The MC1 generates a sinusoidal waveform on the Motor Common output. Depending on which motor is active, it generates a similar waveform displaced in time on one of the individual Motor A, B or C outputs. These waveforms are bipolar, that is, positive or negative with respect to the Motor Ground pins. The magnitudes of each waveform relative to Motor Ground can be configured on the Setup screen. The settings are numbers in the range 0 to 127. These are also shown as voltages. The default values are chosen for the ND3HS1.

The MC1 limits the magnitude of the current on the Motor Common and individual Motor A, B, or C outputs. The current limits help protect the motors from damage, have priority over the voltage magnitude settings, and will automatically limit the actual voltage of the outputs. Use extreme care when increasing these limits, since motor damage can result. The settings are numbers in the range 0 to 127. They are also shown in units of Amps. The default values are chosen for the ND3HS1.

Note that the current firmware does not support reading the current limit settings from the MC1.

MCPlayer can be enabled to write a log file via the Setup dialog. The path and file name of the log file can also be changed. This file may be useful if technical support is needed to resolve problems with the software or hardware. The log is not enabled normally. Your manufacturer support representative may ask for a log file to be created and transmitted to assist in diagnosing any problems.