intan TECHNOLOGIES, LLC

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RHD2000

128 Channel Amplifier Board

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Features

- Small (35 mm x 19 mm x 4 mm), lightweight (1.82 g) circuit board containing two RHD2164 64-channel amplifier chips from Intan Technologies
- Waveforms from 128 electrode channels (electrodes not included) are digitized and transferred over a single serial peripheral interface (SPI) cable
- Integrated electrode impedance measurement capability
- *In situ* constant-voltage or constant-current electroplating capability using optional RHD2000 Electroplating Board
- Compatible with UCLA silicon microprobes; open board design with inexpensive connectors permit other electrodes to be adapted to board
- Dual mounting holes for mechanical stability

Applications

- High density neural recording
- High-channel-count electrode characterization and electroplating

Description

The RHD2000 128 Channel Amplifier Board is the highest density recording module available from Intan Technologies. It is compatible with the RHD2000 Evaluation System, which can support up to two of these boards operating simultaneously. Each 128 Channel Amplifier Board requires only one serial peripheral interface (SPI) cable to provide power and data communication with an RHD2000 USB interface board. (Although each USB interface board has four SPI interface connecters, it can support only two of these 128 channel amplifier boards due to the 256 channel count limit imposed by the bandwidth limit of the USB 2.0 connection to the host computer.)

This 35 mm x 19 mm x 4 mm device weighs 1.82 grams and contains two Intan Technologies RHD2164 64-channel digital electrophysiology interface chips. The chips are wire bonded directly to the printed circuit board and coated in black epoxy to provide protection from dust and light. These chips amplify, filter, and digitize microvolt-level waveforms from 128 electrode channels, serialize this data, and transfer it over a thin SPI cable where it can be viewed and recorded using open-source software from Intan Technologies. The chips also permit *in situ* measurements of all electrode impedances.

Two standard 64-pin Molex connectors provide connection points for an electrode array. Reference and/or ground electrodes may be connected to one of two solder holes on the board. A 12-pin Omnetics connector at the rear of the board provides a connection point for a standard Intan SPI interface cable. Two mounting holes with a center-to-center spacing of 6.0 mm provide a mechanical connection point. These holes each have a diameter of 60 mils (1.52 mm).

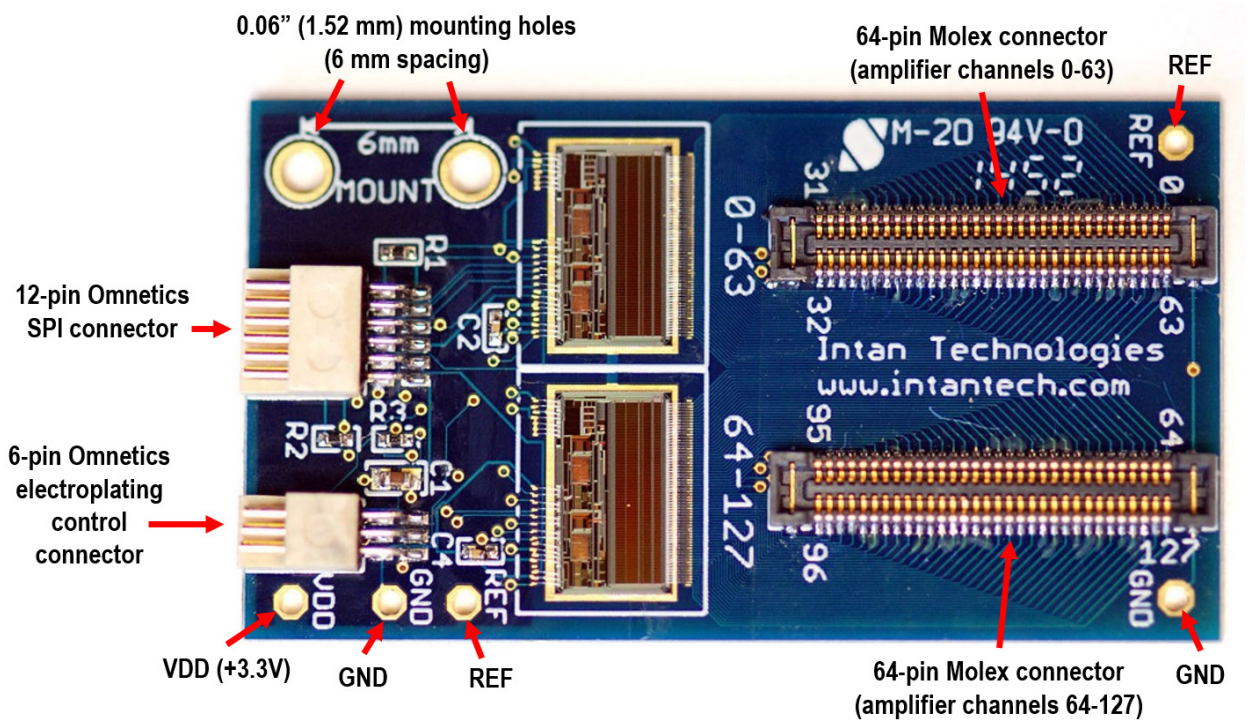
Electroplating Capability

Because few commercially-available 128-channel electrode arrays currently exist, this amplifier board was built to support *in situ* electroplating of electrodes to support users building or customizing their own electrodes. Electroplating is a common electrochemical process used to lower the impedance of microelectrodes by depositing a metal coating onto recording sites from an ionic solution. Common metals used in the electroplating of microelectrodes include gold, platinum, and iridium.

A six-pin Omnetics connector near the SPI connector connects to the optional RHD2000 Electroplating Board, which provides constant-voltage pulses (in the range of ±3.3V) or constant-current pulses (in the range of ±10 µA) that are steered to individual electrode sites to facilitate electroplating. Intan Technologies has developed automated, GUI-controlled software for plating electrodes to desired impedances. The software operates in MATLAB, so the user must have MATLAB, the RHD2000 MATLAB Toolbox, and the RHD2000 Electroplating Board. The datasheet for the RHD2000 Electroplating Board (available at the Intan Technologies website) describes operation of the electroplating software in detail.

If pre-electroplated electrodes are being used with the 128 Channel Amplifier Board then there is no need for the RHD2000 Electroplating Board and associated software. All that is needed is an RHD2000 USB interface board and an SPI interface cable.

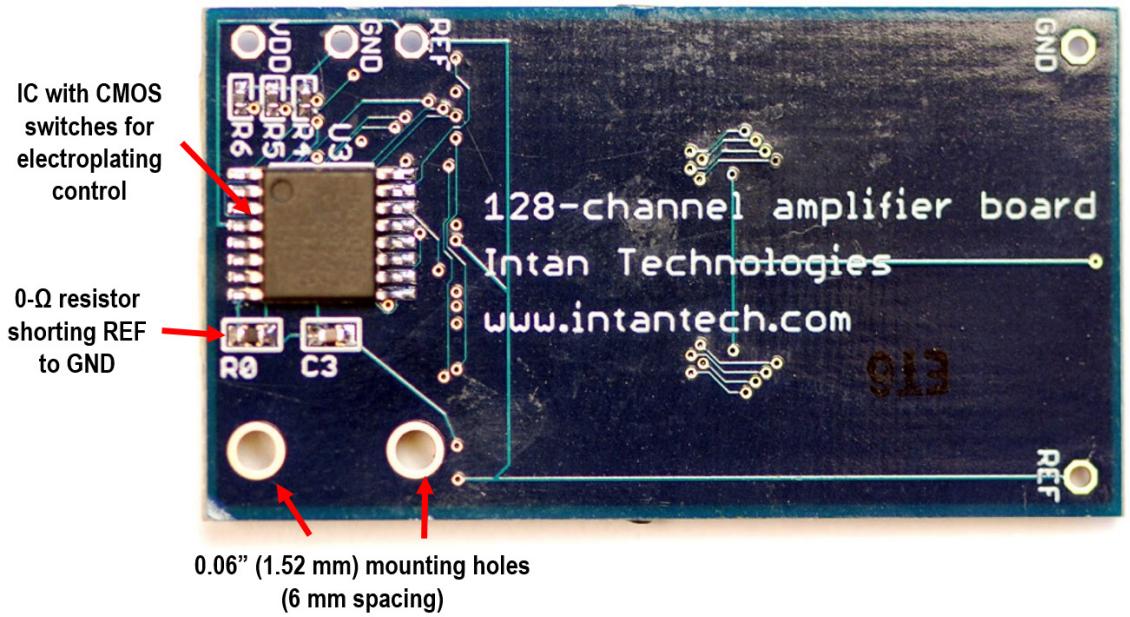
Top View



The 128 Channel Amplifier Board is shown here prior to epoxy coating of the two RHD2164 chips. Two 64-pin Molex connectors are used for electrode connections. The amplifier channel order (indexed from 0 to 127 to remain consistent with Intan data acquisition software) is marked on the circuit board at the four corner pins of each connector. The connectors used on the amplifier board are Molex SlimStack board-to-board connectors with 0.4-mm pitch and a height of 1.0 mm (Molex part number 502426-6410; Digi-Key part number WM24076-ND). The corresponding mating connectors to be used on an electrode board are Molex part number 502430-6410 (Digi-Key part number WM24084-ND; Mouser Electronics part number 538-502430-6410). The center-to-center spacing of these two connectors is 8.8646 mm (0.349 inches). A printed circuit board with 2-mil (50 µm) traces and 2-mil spacing is required to route signals from the RHD2164 chips to these connectors.

It is important to note that these Molex connectors, like virtually all small, dense connectors on the market today, are only rated for a small number of plug-unplug cycles (i.e., 15-20). These numbers cited by the manufacturer are typically very conservative, and Intan adds epoxy to the ends of these connectors to further strengthen them. Still, it is recommended to minimize the number of plug-unplug cycles on these connectors in order to maximize the life of the amplifier board.

Bottom View



The bottom of the 128 Channel Amplifier Board contains a 74HC4053 integrated circuit containing three CMOS switches used for electroplating control. It also contains part R0: a zero-ohm jumper that shorts the reference electrode (REF) to ground (GND). **Note that this part must remain in place during electroplating.** This jumper may be removed for recordings if an independent reference is desired, but most users of Intan amplifier boards obtain excellent recording quality with this part in place (i.e., the reference electrode shorted to ground). Soldering tweezers are the best tool for de-soldering or re-soldering this part.

The 128 Channel Amplifier Board contains solder holes for connecting reference and/or ground electrodes. A low-impedance reference electrode (typically a platinum or Ag/AgCl wire) should be used for all recording configurations. If R0 has been removed, then the tissue should also be connected to ground (GND) somehow (e.g., a skull screw). During electroplating, the ionic plating solution bath must be connected to REF, **not** to GND. For more information, see the RHD2000 Electroplating Board datasheet.

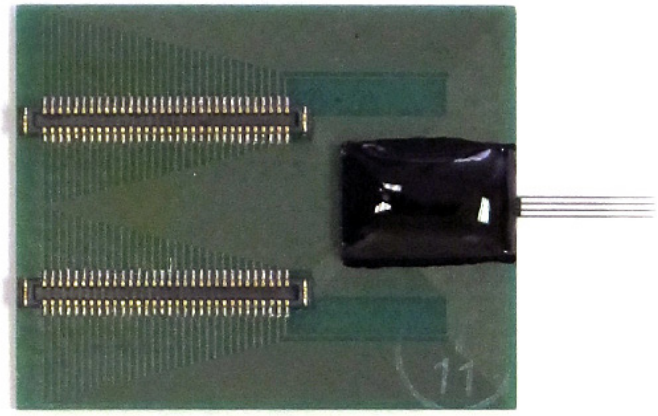
The power supply voltage of approximately +3.3V is available at the VDD solder hole. This can be used to add an LED or other active device to the amplifier board, though devices that pull large amounts of current may cause excessive voltage drops over long SPI cables. For more information, see the **RHD2000 Application Note: Adding an LED to amplifier boards**.

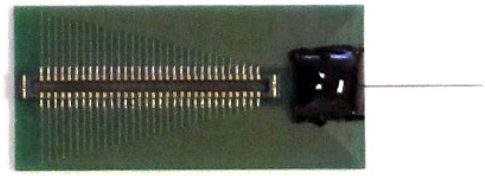
Two mounting holes are available for mechanical attachment. Although they are metal plated, they are electrically isolated from the circuitry in the board.

Probe Design

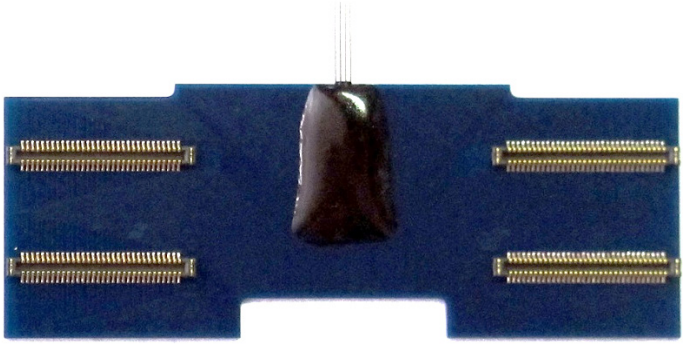
The photo on the right shows a 128-channel UCLA silicon microprobe developed by Prof. Sotiris Masmanidis. The probe is wire-bonded and epoxied to a printed circuit board with two Molex SlimStack 502430-6410 connector spaced exactly 8.8646 mm (0.349 inches) apart. This probe mates with the RHD2000 128 Channel Amplifier Board.

See **http://masmanidislab.neurobio.ucla.edu/technology.html** for more information.





The photo above shows a 64-channel UCLA silicon microprobe. One of these probes may be connected to either Molex connector on the RHD2000 128 Channel Amplifier Board.

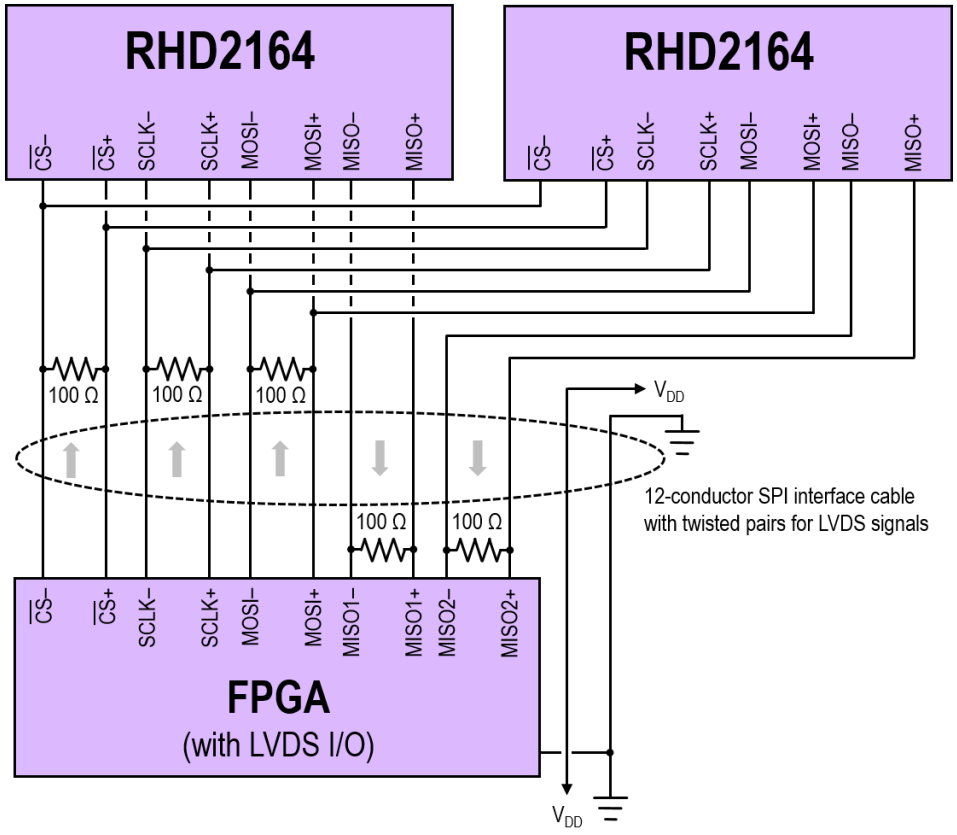


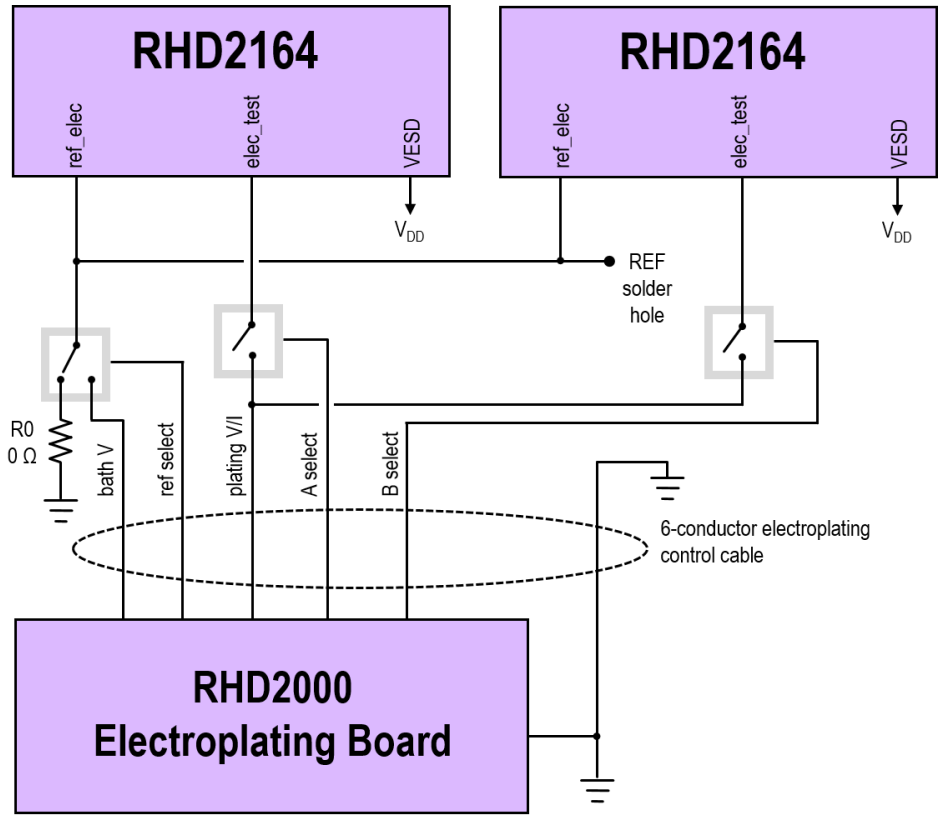
The photo above shows a 256 channel UCLA silicon microprobe. Two RHD2000 128 Channel Amplifier Boards may be connected to this probe (one on either side) to fully instrument all 256 recording sites.

Circuit Design

Serial Peripheral Interface

The RHD2000 128 Channel Amplifier Board uses all 12 wires in the SPI interface cable to power and communicate with two RHD2164 chips. The diagram below shows a simplified version of the LVDS (low voltage differential signaling) SPI buses used on the board. Both chips receive the same commands, but they send data back on two MISO (master in, slave out) paths. More information on this communication method may be found in the **RHD2000 Series Datasheet**, the **RHD2164 Datasheet**, and the **RHD2000 SPI cable/connector specification**. All documents may be found on the Downloads page at the Intan Technologies website.





Electroplating Control

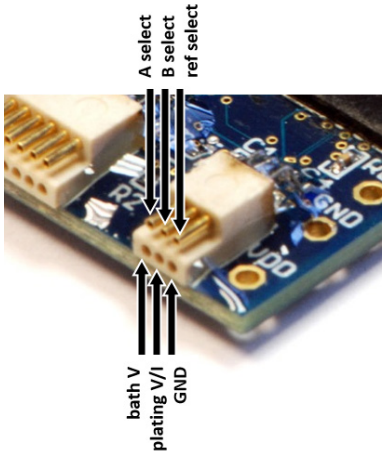
The above diagram shows circuit connections that are relevant for the electroplating capability of the RHD2000 128 Channel Amplifier Board. The **VESD** pin of each RHD2164 chip is tied to the positive power supply (VDD) which allows the DC input levels at each electrode to range between ground and +3.3 V without activating the on-chip ESD (electrostatic discharge) protection diodes. A 74HC4053 integrated circuit on the bottom of the circuit board contains three CMOS switches that are used for electroplating control. The RHD2000 Electroplating Board provides two analog signals (**bath V** and **plating V/I**) and three digital signals (**ref select**, **A select**, and **B select**) to the amplifier board.

The **A select** and **B select** signals connect the **elec_test** pin from either RHD2164 chip to the **plating V/I** pin, which supplies a DC voltage or current used for electroplating. (**A select** and **B select** should never be high at the same time, and they should both be low during normal amplifier operation or impedance measurement.) The voltage on **plating V/I** should always remain between ground and +3.3 V. Switches internal to each RHD2164 chip route the signal from **plating V/I** to one selected electrode. See the **RHD2000 Series datasheet** for more details.

The **ref select** signal connects the amplifier reference input, as well as the electroplating solution (which should be connected to the REF pin with a low-impedance wire) to the analog voltage **bath V**. This voltage must be set between ground and +3.3 V, which allows the electrodes to be plated used negative voltages (with respect to the plating solution). The **ref select** signal should always be low during normal amplifier operation or impedance measurement. See the **RHD2000 Electroplating Board datasheet** for more information on these procedures.

The amplifier board contains pull-down resistors to ensure that the CMOS switches remain in the positions shown above when the electroplating control cable is unconnected. These default positions disable plating and allow the chips to operate normally for amplifier and impedance measurement functions when not connected to the electroplating control board.

The diagram to the right shows the location of these electroplating control signals on the 6-pin Omnetics polarized nano connector (PZN-06).



Related RHD2000 Documentation

The following supporting datasheets may be found at **http://www.intantech.com/downloads**:

- **RHD2000 Series Digital Electrophysiology Interface Chips**
- **RHD2164 Digital Electrophysiology Interface Chip**
- **RHD2000 Electroplating Board**
- **RHD2000 Evaluation System**
- **RHD2000 USB/FPGA Interface: Rhythm**
- **RHD2000 SPI Cable/Connector Specification**
- **RHD2000 USB Evaluation System Catalog**

Application Notes:

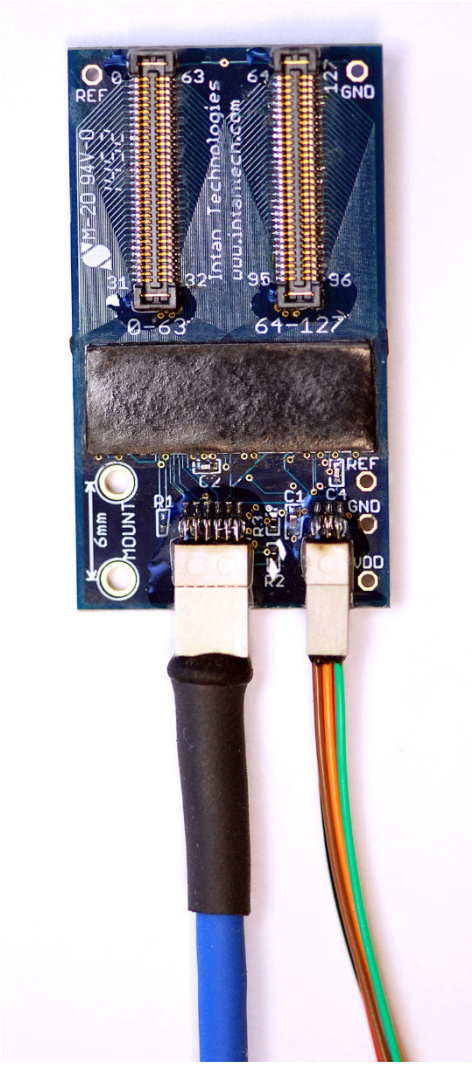
- **RHD2000 Application Note: Data File Formats**
- **RHD2000 Application Note: I/O Voltage Level Shifting**
- **RHD2000 Application Note: Adapting SPI Cables to a Commutator**
- **RHD2000 Application Note: Adding an LED to Amplifier Boards**

Schematics of all circuit boards are available from Intan Technologies.

Contact Information

This datasheet is meant to acquaint engineers and scientists with the RHD2000 128 Channel Amplifier Board developed at Intan Technologies. We value feedback from potential end users. We can discuss your specific needs and suggest a solution tailored to your applications.

For more information, contact Intan Technologies.



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