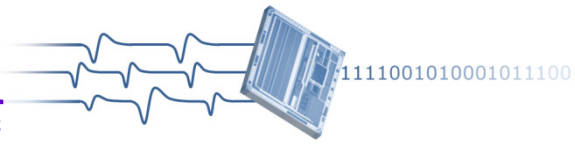
intan TECHNOLOGIES, LLC



RHS2000

SPI Stim Interface Cable/ Connector Specification

24 January 2017

Features

- Self-aligning standard Omnetics PZN-16 polarized nano connectors; no guide pins required
- Twisted pairs in cable facilitate the use of LVDS (low-voltage differential signaling) communication for low-noise operation and high signal integrity over long distances
- 16-conductor cable contains four power wires and six LVDS pairs: one cable can support two RHS2116 chips
- Small connector size: 5.7 mm × 4.3 mm × 2.0 mm
- Cable design permits daisy-chaining for easy adjustment of cable length

Applications

- RHS2000-based electrophysiology stimulation and signal acquisition systems
- Starting point for the development of custom connectors to RHS2000 stimulator/amplifier chips

Cable Description

To support the evaluation system for the RHS2000 series of digital stimulator/amplifier chips, Intan Technologies has developed a standard interface cable and connector scheme to transmit digital low-voltage differential signaling (LVDS) data and power over distances of several meters. These cables allow RHS2000-based electrophysiology amplifier boards or headstages to be located some distance from the USB/FPGA controller that controls the chips and streams data from them into a host computer. The design of this cable is quite simple, and can serve as an example for more sophisticated variations of wired interfaces to RHS2000 chips.

The cable described here supports the serial peripheral interface (SPI) communication scheme used by RHS2116 chips to receive commands and transmit digitized signals from biopotential amplifiers. The 4-wire SPI interface uses a chip select ($\overline{CS}$) signal and a serial clock (SCLK) signal to sequence 32-bit data words. The MOSI (master out, slave in) signal transmits commands from the SPI master to the RHS2116 chip. A MISO (master in, slave out) signal is used by each RHS2116 chip to send data back to its controller. (See the RHS2116 datasheet for more details on this communication protocol.)

Each RHS2000 SPI cable contains 16 conductors: four thicker wires for power (+3.3V), ground, and the stimulation power supplies VSTIM+ and VSTIM– (typically +9V and -9V), and 12 thinner wires arranged in six twisted pairs for six LVDS digital signals. The six LVDS signal paths in the cable allow for two MOSI lines and two MISO lines so that two RHS2116 chips may send data over one cable while receiving independent command streams from a controller. This allows for the construction of a 32-channel recording headstage (i.e., two RHS2116 chips) using only one cable. The use of terminated, twisted-pair data wires and LVDS signaling eliminates the need for any conductive shielding on the cables.

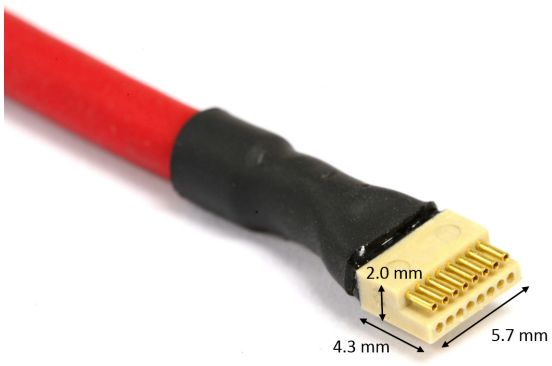


Figure 1. Dimensions of a RHS2000 Stim SPI connector from Intan Technologies. The connector on each end is a self-aligning 16-pin Omnetics PZN-16 polarized nano connector.

Figure 2. Standard cable with red TPE jacket removed. This reduces the cable diameter to 2.4 mm and increases flexibility somewhat.

The cables use self-aligning 16-pin Omnetics PZN-16 polarized nano connectors at each end. Figure 1 above shows the end of a cable with connector dimensions indicated.

Intan Technologies supplies RHS2000 Stim SPI cables in fixed lengths. Cables are available in 3-foot (0.9-meter) and 6-foot (1.8-meter) lengths.

RHS2000 Stim SPI cables have a diameter of 3.4 mm and a mass of 11.88 g/m. Each connector and associated protective sheathing adds roughly 0.21 g. The power wires in a standard cable are 32 AWG wire (with a conductor diameter of 202 µm) and have a DC resistance of 0.564 Ω/m. The LVDS signal wires use 36 AWG wire (with a conductor diameter of 127 µm) and have a DC resistance of 1.39 Ω/m. At typical SPI data frequencies in the MHz range, resistance will increase due to the skin effect.

The cable diameter of 3.4 mm includes a flexible red thermoplastic elastomer (TPE) jacket that may optionally be removed by carefully cutting through this material and peeling it away. Removing the red TPE jacket reduces diameter of the cable to 2.4 mm and increases its flexibility somewhat. This reduces the mass of the cable to 7.34 g/m. The wire bundle is wrapped in white paper tape. If this tape begins to unravel, it can be bound by periodic segments of standard 3/16" diameter heat-shrink tubing (e.g., Digi-Key part number RNF316K-ND). The tubing should be cut into short segments and slid onto the cable where heat can be applied to shrink it into place where desired.

The twisted-pair data lines have characteristic impedances (Z_0) close to the 100-Ω standard used in LVDS termination to minimize signal reflections. Detailed physical and electrical characteristics of the RHS2000 Stim SPI cables are listed on the following page.

Physical and Electrical Characteristics

PARAMETER	VALUE	UNITS	COMMENTS
Cable diameter	3.4 2.4	mm mm	Including outer jacket With outer jacket removed
Cable cross-sectional area (related to cable flexibility)	9.1 4.5	mm^2 mm^2	Including outer jacket With outer jacket removed
Cable mass	11.88 3.62 7.34 2.24	g/m g/ft g/m g/ft	Including outer jacket With outer jacket removed
Outer jacket material	red 0.013” thermoplastic elastomer (TPE)		
Inner wrap material	0.001” paper tape		
Wire insulation material	0.006”/0.005” PVC		
Wire gauge and conductor diameter: power wires	32 202	AWG µm	4 power wires per cable
Wire gauge and conductor diameter: data wires	36 127	AWG µm	12 data wires are grouped in 6 twisted pairs for LVDS signals
Number of Intan RHS2116 chips supported per cable	2		Two chips supported with independent command lines
Power wire DC resistance	0.564 0.172	Ω/m Ω/ft	
Data wire DC resistance	1.39 0.423	Ω/m Ω/ft	Resistance at typical SPI data frequencies will be up to 65% higher due to skin effect
Data wire twisted pair inductance (L')	810 247	nH/m nH/ft	
Data wire twisted pair capacitance (C')	55.8 17.0	pF/m pF/ft	
Data wire twisted pair characteristic impedance (Z_0)	120	Ω	$Z_0 = \sqrt{L'/C'}$ Close to 100-Ω LVDS standard
Data wire twisted pair propagation speed (v)	0.149 0.488 0.50	m/ns ft/ns c	$v = 1/\sqrt{L'C'}$ c = speed of light
Connector type	Omnetics PZN-16 polarized nano		See www.omnetics.com
Connector size	5.7 × 4.3 × 2.0	mm^3	
Connector mass	0.097	g	Approximately 0.207 g including protective sheathing and epoxy used in cables

Cable Wiring and Pin Locations

RHS2000 Stim SPI cables mate with any Omnetics PZN-16 connector (see **www.omnetics.com**). For printed circuit board (PCB) applications, the most convenient connector to use is the PZN-16-AA (Omnetics part number A79633-001), shown in Figure 3 below. Figure 4 shows the recommended PCB footprint for surface-mount attachment.

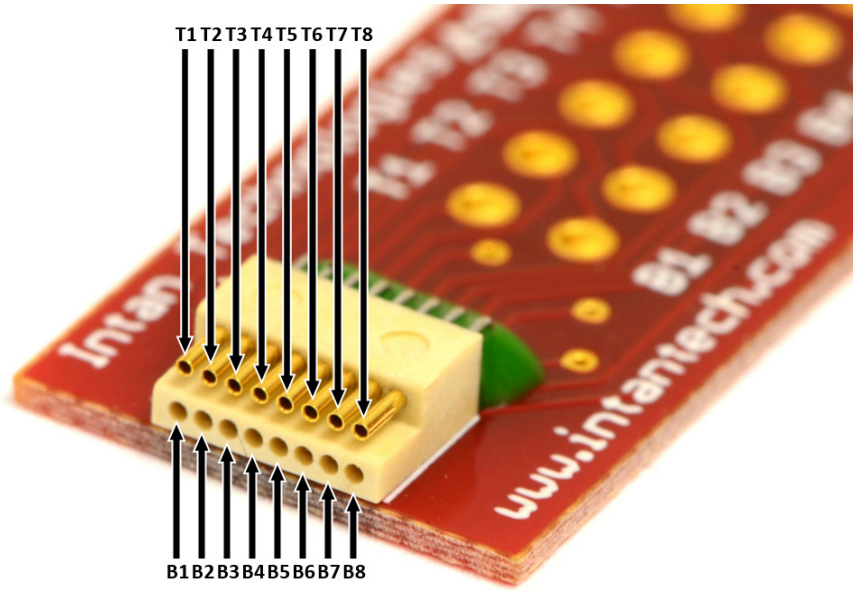


Figure 3. Omnetics PZN-16-AA 16-pin polarized nano connector (part number A79633-001) with Intan Technologies pin numbers (**T** = top, **B** = bottom).

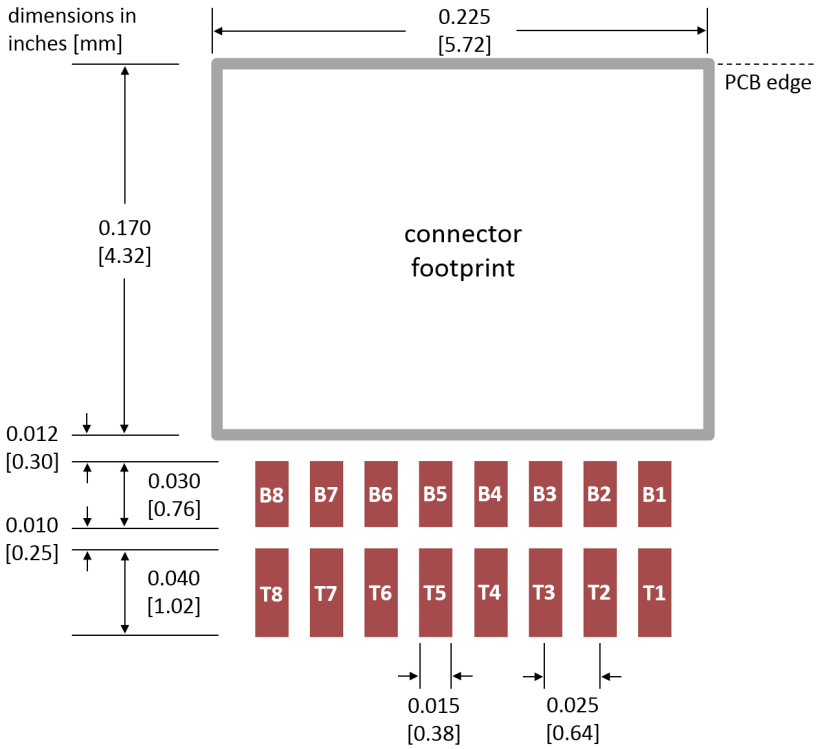


Figure 4. Printed circuit board (PCB) footprint for Omnetics PZN-16-AA connector (part number A79633-001).

Table 1 lists the pin locations for each signal in the Stim SPI cable. Note that the pin locations are different for the connections on the SPI master side (i.e., the data acquisition controller, such as a microcontroller or FPGA) and the SPI slave side (i.e., the headstage containing the RHS2000 chip): the "top" and "bottom" pins are inverted.

Table 1. Pin locations of Stim SPI signals and power wires

Signal	PZN-16-AA pin number (SPI master side: CPU or FPGA)	PZN-16-AA pin number (SPI slave side: RHS2000 chip)
$\overline{CS}$+	T6	B6
$\overline{CS}$–	T7	B7
SCLK+	B3	T3
SCLK–	B2	T2
MOSI1+	B5	T5
MOSI1–	B4	T4
MOSI2+	T4	B4
MOSI2–	T5	B5
MISO1+	B7	T7
MISO1–	B6	T6
MISO2+	T2	B2
MISO2–	T3	B3
Power (+3.2V – +3.6V)	B8	T8
Ground	T8	B8
VSTIM+	T1	B1
VSTIM–	B1	T1

As Table 1 illustrates, LVDS signal pairs and the two power lines are paired vertically on each connector and within the cable. Each SPI cable is wired in a manner that permits multiple cables to be daisy chained (i.e., connected in series) to form a longer cable. Figure 5 below shows the nature of the connections. (The twisted geometry of each signal pair is omitted in this diagram to aid clarity.)

Figure 5. Cross-sectional schematic of cable showing connector wiring.

Conceptually, all signals are passed straight through the cable from one connector to an inverted connector on the other end. This allows signals to pass straight through daisy-chained cables when the polarized nano connectors are mated as shown in the diagram and photo below:

Figure 6. Illustration of daisy chaining multiple cables together.

Figure 7. Photograph of two cables daisy chained together.

While this wiring scheme allows multiple cables to be connected serially, it is important to recognize that it also renders any color coding of wires in the cable ambiguous. In the diagram below, we show a red wire and a blue wire. Let's assume that one of these wires carries the +3.3V power signal and the other wire is ground. For a general cable, we cannot say that the red wire is power and the blue wire is ground, because if the cable is flipped and connected in the opposite direction the roles of these two wires reverse (see Figure 8 below). This is an important fact to remember if custom cables are developed based on this wiring scheme.

Figure 8. Schematic of cable in two possible orientations.

When creating long cables, it is important to consider the voltage drop along the power lines. The RHS2116 datasheet gives supply current estimates for the chip in various configurations; these should be multiplied by the series resistance of both the power line **and** the ground line in the cable to calculate voltage drop. Since the RHS2116 can operate at full specifications up to a supply voltage range of 3.6V, it may be desirable to supply a regulated voltage near 3.6V to allow for several hundred millivolts of loss across the power line resistance in long cables. (The Intan Stim/Record Controller provides a 3.5V supply to its SPI ports.)

The series resistance of the LVDS signal wires is less critical. As long as the total series resistance of **both** wires in a twisted pair is significantly less than the 100 Ω termination resistance, long cables will have little effect on LVDS signal integrity.

Development Products

Intan Technologies supplies RHS2000 Stim SPI cables in fixed lengths. Figure 9 shows the 3-foot (0.9-meter) interface cable; 6-foot (1.8-meter) cables are also available.

A Stim SPI cable adapter circuit board is also available (see Figure 10). This simple circuit board brings out the signals from all twelve conductors (labeled T1-T8 and B1-B8) to 0.1"-pitch solder holes. This may be used to interface RHS2000 Stim SPI cables to prototype devices without using Omnetics PZN-16-AA connectors. This board may be used to connect SPI signals to a commutator, as described in the **RHS2000 Application Note: Adapting Stim SPI Cables to a Commutator**, available from the Downloads page on the Intan Technologies website.

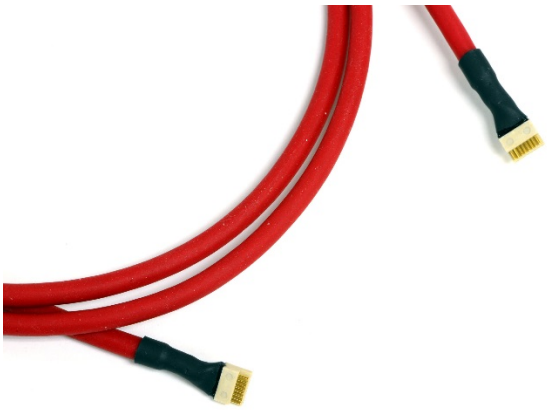


Figure 9. RHS2000 Stim SPI interface cable

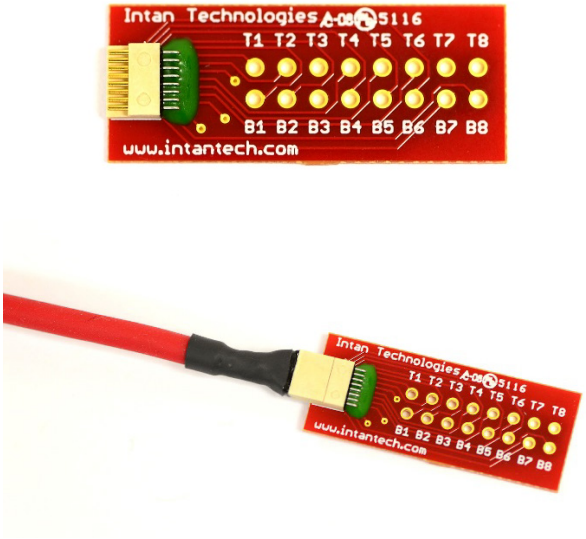


Figure 10. RHS2000 Stim SPI cable adapter circuit board available from Intan Technologies.

Related Documentation

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

- **RHS2000 Application Note: Adapting Stim SPI Cables to a Commutator**
- **RHS2116 Series Digital Electrophysiology Stimulator/Amplifier Chips**
- **RHS2000 Stim/Record System User Guide**