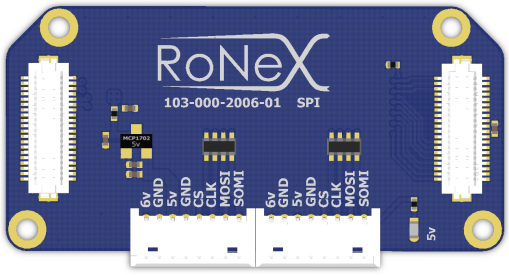
RoNeX



RNX-011

SPI Module Specifications

The RoNeX SPI Module provides four independent SPI ports for connecting a wide range of external devices, such as DACs, high performance sensors or ICs. It also provides general purpose Digital I/O and Analogue Inputs.

Specifications

Power Consumption	3W max
SPI	
SPI Ports	4
SPI slaves	Up to 10
Throughput	256kbps / port
Analogue	
Inputs	6
Input Impedance	43kΩ
Sample Rate	1kHz
Resolution	12 bit

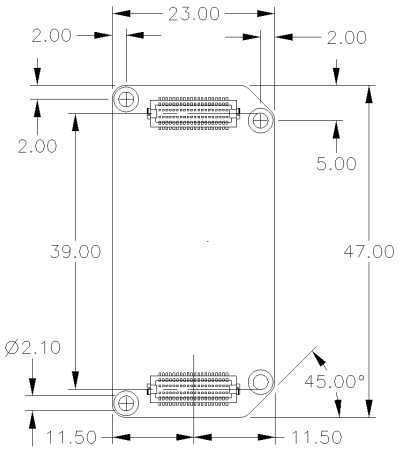
Features

- 4 independent SPI Master ports
- Supports up to 10 SPI slave devices
- 6 Analogue Inputs
- 6 General Purpose Digital I/O
- Micro form factor
- Expandable and Scalable

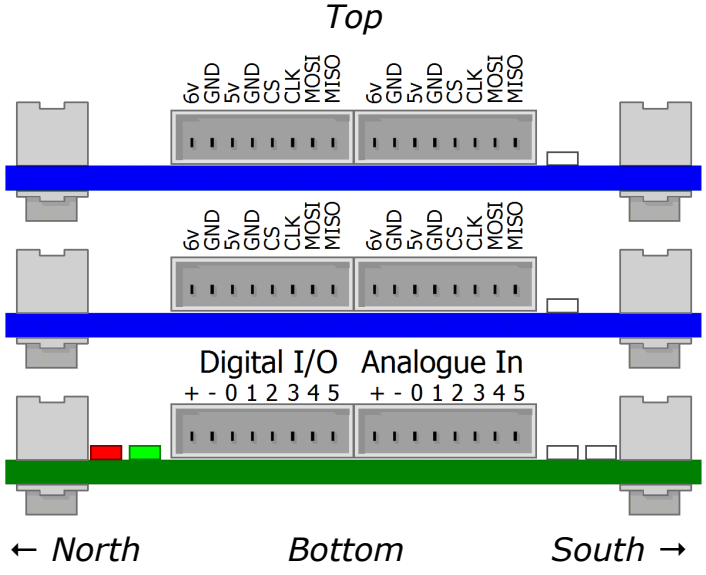
Applications

- Ideal for advanced robot hardware
- Connect a variety of SPI slave devices

Dimensions [mm]



Connectors



All six connectors are Molex Picoblades, model number:

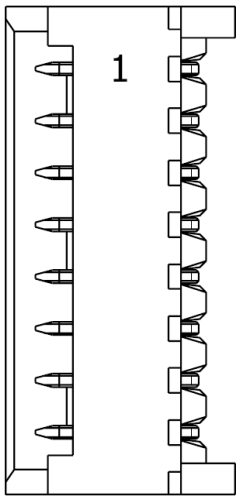
Molex Picoblade 53048-0810 (8-way RA TH)

Pre-assembled cables and crimps are available from Shadow Robot and most electronics distributors.

Digital I/O Connector

Located at the North side of the Module, bottom (green) board:

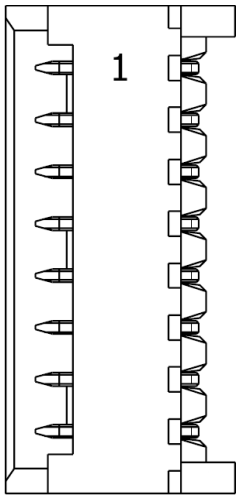
Pin Function	Pin #
5v (V+)	1
GND (V-)	2
Digital IO Ch0	3
Digital IO Ch1	4
Digital IO Ch2	5
Digital IO Ch3	6
Digital IO Ch4	7
Digital IO Ch5	8



Analogue Input Connector

Located at the South side of the Module, bottom (green) board.

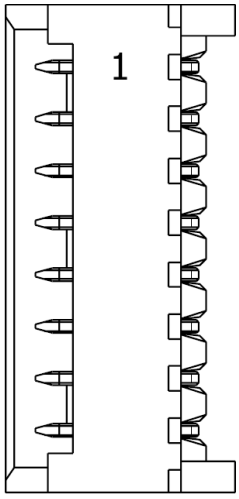
Pin Function	Pin #
5v (V+)	1
GND (V-)	2
Analogue In Ch0	3
Analogue In Ch1	4
Analogue In Ch2	5
Analogue In Ch3	6
Analogue In Ch4	7
Analogue In Ch5	8



SPI Connectors

All four connectors on the top two (blue) boards:

Pin Function	Pin #
6v (V+)	1
GND (V-)	2
5v (V+)	3
GND (V-)	4
Chip Select (CS)	5
Clock (CLK)	6
Master-Out Slave-In (MOSI)	7
Slave-Out Master-IN (SOMI)	8



The SPI connectors provide both 6v from a DCDC converter and 5v from a linear regulator. Either or both supplies can be used to power an attached SPI device. Many high quality mixed signal devices, like high resolution ADCs and DACs recommend dual power supplies for the analogue and digital parts of the device. These devices can use the 6v pin to supply local linear regulators.

Analogue and Digital Channels

Digital I/O

The Digital connector provides DC power and in total six general purpose I/O channels that can be configured as inputs or outputs dynamically from the Host (an EtherCAT Master device, such as a PC running ROS). The connector supplies 5v power to pins 1 (V+) and 2 (V-), and can be used to power sensors or devices up to a maximum of 70mA. The six I/O channels are labelled *Ch0* to *Ch5*. The pin states can be set or read from the host at 1kHz. The digital channels may also be used as Chip Select so that additional SPI slave devices may be connected to the module.

Parameter	Description	Conditions	Min	Typ	Max	Units
V_{DIO}	DC input voltage	Relative to v- pin	-0.1		5.1	V
V_{IH}	Input high threshold	Relative to v- pin	3.5			V
V_{IL}	Input low threshold	Relative to v- pin			1.3	V
I_{DIO}	DC output current		-16		16	mA
V_{OH}	Output voltage high	Relative to v- pin	3.0			V
V_{OL}	Output voltage low	Relative to v- pin			0.6	V

V_P	Power supply voltage	From v+ / v- pins	4.85	5.0	5.15	V
I_P	Power supply current	From v+ / v- pins			70	mA

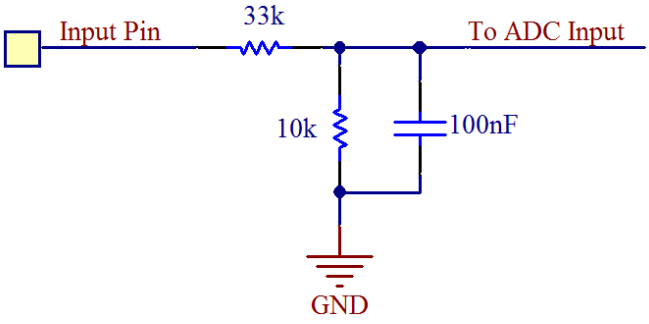
Digital I/O pins each have a 300Ω protection series resistor. This limits the current to a safe level of 16mA in the event of a short to 5v or GND.

Analogue Inputs

The Analogue connector provides separately regulated DC power and six analogue input channels. The connector supplies 5v power to pins 1 (V+) and 2 (V-), and can be used to power sensors or devices up to a maximum of 100mA. The six input channels are labelled *Ch0* to *Ch5*. The sensed input voltages can be read by the Host at 1kHz.

Parameter	Description	Conditions	Min	Typ	Max	Units
V_{AI}	Input voltage	Relative to v- pin	0.01		4.4	V
R_{AI}	Resolution			12		bits
S_{AI}	Step size			1		mV
V_P	Power supply voltage	From v+ / v- pins	4.85	5.0	5.15	V
I_P	Power supply current	From v+ / v- pins			100	mA

Each analogue input pin is filtered with the RC filter below:



Analogue and Digital Power

The analogue and digital connectors are supplied by separate linear regulators. This means digital switching noise is not coupled into the analogue supply, giving much lower noise for analogue sensing. It also means that the current available from the analogue port is separate from the current available from the digital port. Devices may draw 70mA from the digital port, *and* 100mA from the analogue port. See the section on Power Consumption below for details of the maximum allowable current draw.

ADC performance

The analogue inputs use a Delta-Sigma ADC to convert the analogue voltage

into a digital value. While this type of ADC gives an excellent signal to noise ratio, it can be unstable at the high and low extremes of its input range. For this reason, input voltage should not be allowed to drop below 0.1v, or rise above 4.4v. No harm will come to the device however if the voltage is within -0.3v to 5.3v.

SPI Transactions

EtherCAT Packets

SPI transactions are initiated when an EtherCAT packet arrives from the Host. The packet contains any outgoing SPI data for all four SPI ports, plus any configuration, Chip Select and Digital I/O settings. As ROS runs a 1kHz real-time loop, SPI transactions can only happen at most once every millisecond when using ROS.

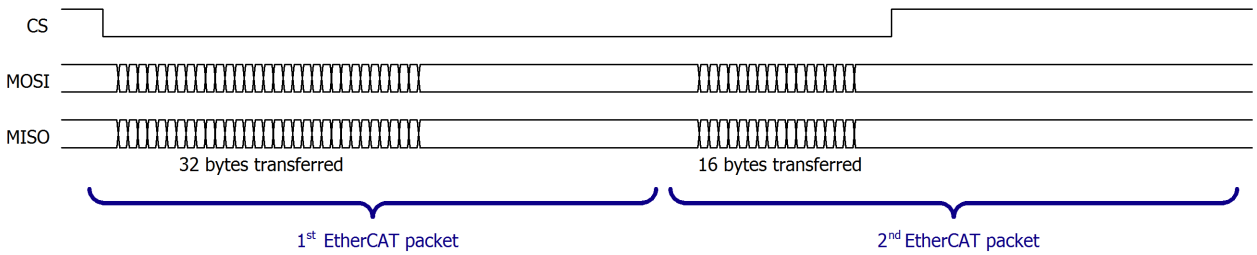
Chip Selects

The SPI transactions on the SPI Module is designed for flexibility, and are able to interface with many types of SPI devices. The Module contains four SPI ports, and is capable of performing one SPI transaction per port per millisecond. Each port has its own Chip Select pin, but alternatively any of the six digital pins can be used as Chip Select lines. This gives a total of ten possible chip select pins to allow up to ten SPI slaves to be attached to the SPI Module.

Data transfer

For each EtherCAT packet, each SPI port can transfer a maximum of 32 bytes of data; 32 bytes sent from the Host to the peripheral device, and 32 bytes returned from the peripheral device back to the Host.

Transactions consisting of more than 32 bytes will be split up across multiple EtherCAT packets, with the chip-select asserted before the first packet, and de-asserted after the last packet.



For example, a transfer of 48 bytes would be split across two EtherCAT packets. This happens transparently to the Host except that the transfer would take one extra millisecond to complete, and so reduces the maximum number of transactions per second to 500.

Long duration transactions

Even when the transaction size is 32 bytes or less, using a very slow clock rate may result in a transaction which takes longer than one EtherCAT frame (1ms) to complete. In this case, the Module will return the data when it is all received. The Host will wait.

Since all SPI ports operate together, a long duration transaction on one port will delay any short duration transactions on other ports.

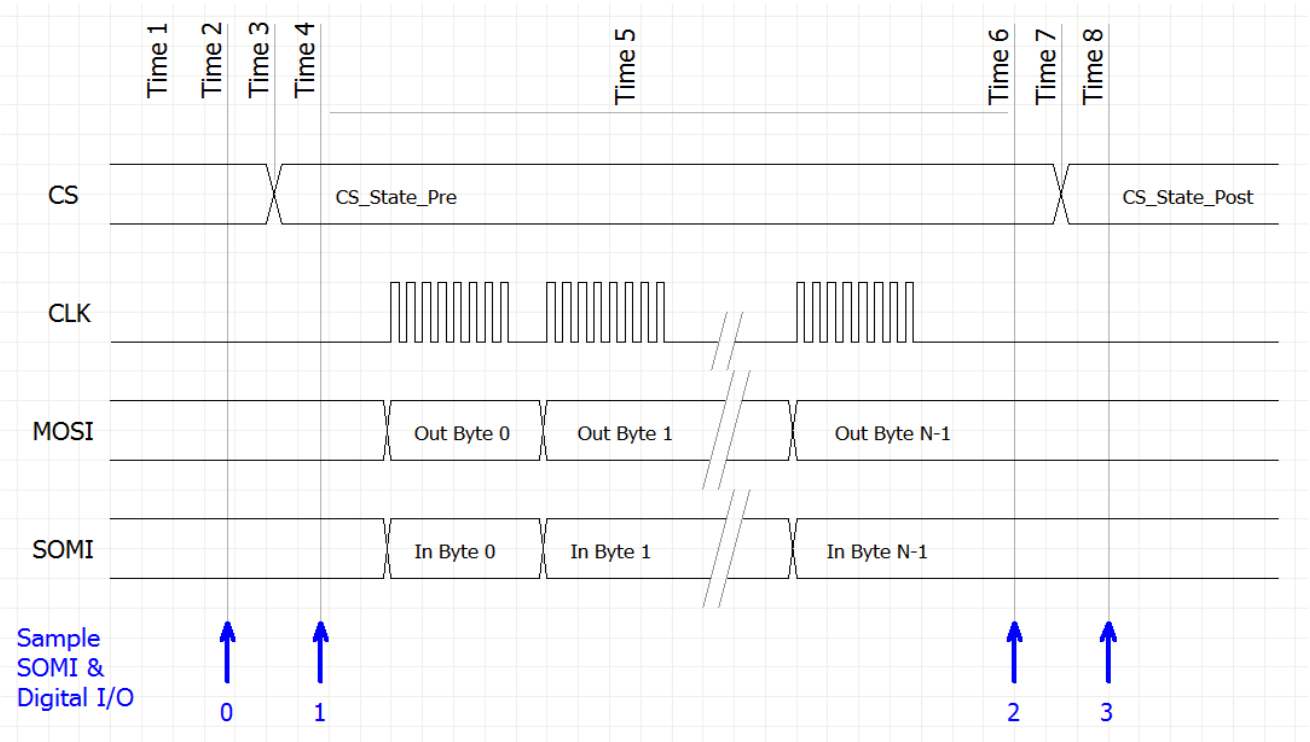
Sampling

Some SPI devices allow/require a sample to the MISO line after the Chip Select is asserted, but before the first clock pulse. The SPI Module samples all four MISO lines and six digital lines before and after each Chip Select event, and returns this data to the host, along with the incoming SPI data.

SPI Clock

Each SPI port contains an independent clock whose frequency is of the form 32MHz/N where N is an integer in the range 1..65535. The clock can be set independently for each port, and for each transfer, so it is possible to communicate with multiple devices at different speeds, however they are connected to the SPI Module.

General Transaction Sequence

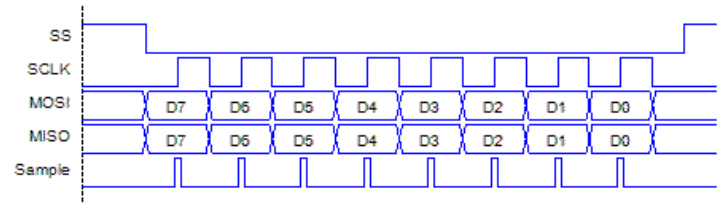
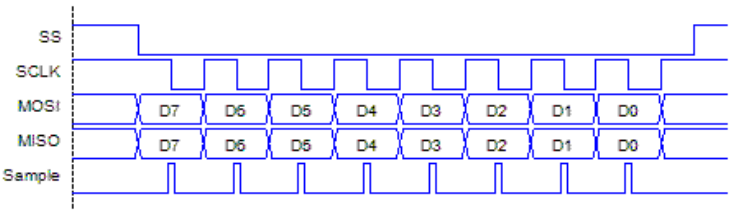
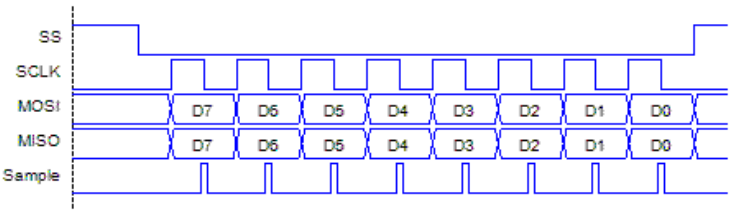
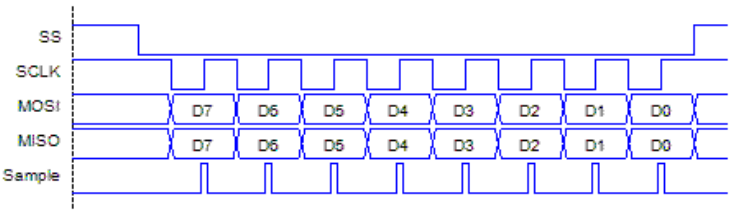


Time	Action
Time 1	EtherCAT packet arrives
Time 2	Digital I/O and SOMI lines are sampled (0)

Time 3	Digital I/O and CS lines are set to 'pre' state
Time 4	Digital I/O and SOMI lines are sampled (1)
Time 5	N bytes are transferred
Time 6	Digital I/O and SOMI lines are sampled (2)
Time 7	Digital I/O and CS lines are set to 'pre' state
Time 8	Digital I/O and SOMI lines are sampled (3)

SPI Modes

All four SPI modes are available. The mode of each SPI port can be set independently by the host.

Mode 00: Clock normally low Data changes on falling edge	
Mode 01: Clock normally high Data changes on rising edge	
Mode 10: Clock normally low Data changes on rising edge	
Mode 11: Clock normally high Data changes on falling edge	

Power Consumption

Number of SPI Modules	Maximum current from each 6v pin on SPI ports	Maximum current from each 5v pin on SPI ports
1	500mA	100mA
2	250mA	100mA
3	125mA	90mA
4	60mA	75mA
5	30mA	60mA

Exceeding these limits may cause system instability or even permanent damage to some or all the Modules.

LEDs

The SPI Module includes LEDs to display the following status:

Name	Colour	Meaning	Behaviour	
Run	Green	EtherCAT field-bus communication status of Module	- Off: - Blinking: - Flash: - On:	Init state Pre-operational Initialisation Operational
Error	Red	EtherCAT Error Indicator	- Off: - On:	No Error Error
5v	White	5v regulator power availability status	- Off: - On:	Power Off Power On
6v	White	6v regulator power availability status	- Off: - On:	Power Off Power On

Software user manuals

A full user manual on using RoNeX with ROS is available on the ROS Wiki:

http://wiki.ros.org/sr_ronex

A full user manual on using RoNeX with MATLAB is available here:

https://github.com/shadow-robot/sr-RoNeX/wiki/RoNeX-plus-Matlab

For more details please visit the RoNeX product page at:

http://www.shadowrobot.com/products/ronex