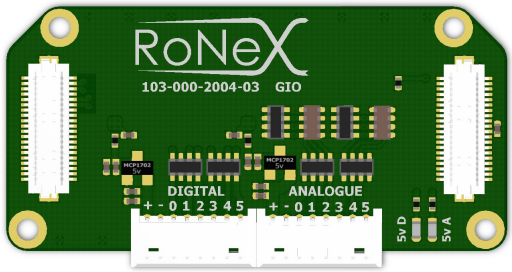
RoNeX



RNX-010

General I/O Module Specifications

The RoNeX GIO Module is a general purpose input / output unit for connecting sensors and actuators providing real-time 12 analogue sensing channels and digital control via 12 general purpose digital I/O channels.

Specifications

Power Consumption	3W max
Analogue	
Inputs	12
Range	0.1v – 4.4v
Input Impedance	43kΩ
Resolution	12 bit
Sample Rate	1kHz
ADC Type	Delta Sigma
Digital	
Inputs/Outputs	12
Output Impedance	300Ω

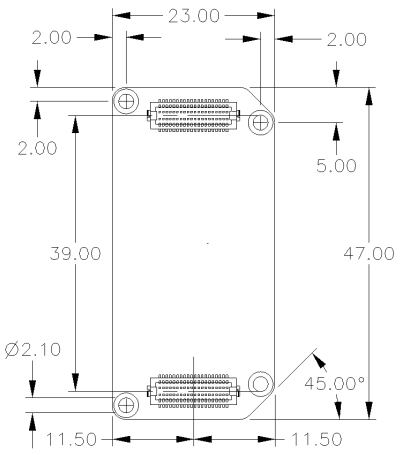
Features

- 12 Analogue Inputs
- 12 general purpose Digital I/O
- Independent PWM mode for each D I/O
- Expandable and scalable
- Independent digital & analogue power regulation for analogue noise reduction

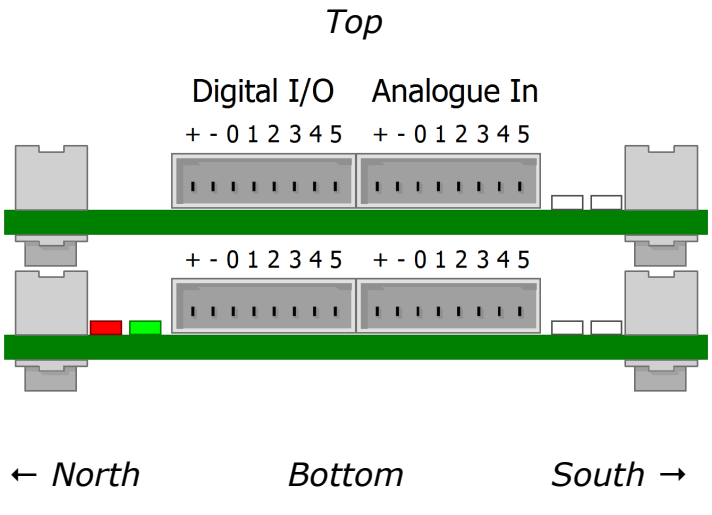
Applications

- Ideal for general robot control
- Motor & servo-motor control
- Analogue or digital sensor reading
- Rapid prototyping and lab testing
- Integration into final designs

Dimensions [mm]



Connectors



Connectors

All four connectors are Molex Picoblades, model number:

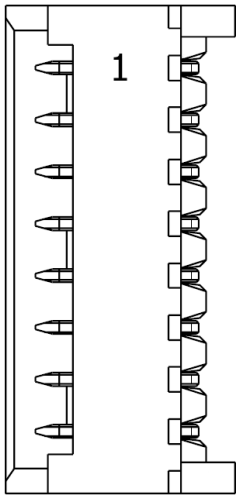
Molex Picoblade 53048-0810 (8-way RA TH)

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

Digital I/O Connectors

Located at the North side of the Module.

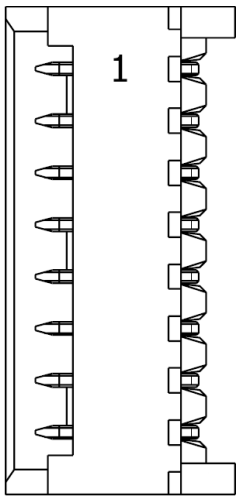
Pin Function	Pin #
5v (V+)	1
GND (V-)	2
Digital IO Ch0	3
Digital IO Ch1	4
Digital IO Ch2	5
Digital IO Ch3	6
Digital IO Ch4	7
Digital IO Ch5	8



Analogue Input Connectors

Located at the South side of the Module.

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



Digital I/O

The Digital connectors provide DC power and a total twelve 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). They can also be set as PWM outputs. Each 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 twelve I/O channels are labelled *Ch0* to *Ch11*. The pin states can be set or read from the host at 1kHz.

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.

PWM Mode

PWM Master Clock

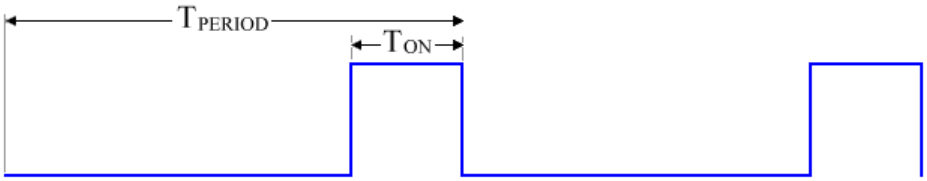
A PWM Master Clock drives six PWM Generators. The base frequency of the Master Clock is 64MHz.

This frequency can be reduced by dividing by a 16-bit integer (1 .. 65535), allowing a minimum Master Clock frequency of 976.6Hz.

PWM Generators

The GIO Module contains six PWM Generators which generate the PWM signals for each digital channel.

Each PWM Generator drives two channels with the condition that those two channels have the same *period*. However, each channel in a pair can have an independent *on-time*.



Each Generator has its own *period* and two *on-times* as shown in the table below where each `parameter` set by the Host is highlighted:

Master Clock	Generator Period	Channel On-time	Output Channel
Master Clock (64Mhz) `clock_divider`	`Period_0`	`On-time_0`	Digital I/O Ch0
		`On-time_1`	Digital I/O Ch1
	`Period_1`	`On-time_2`	Digital I/O Ch2
		`On-time_3`	Digital I/O Ch3
	`Period_2`	`On-time_4`	Digital I/O Ch4
		`On-time_5`	Digital I/O Ch5
	`Period_3`	`On-time_6`	Digital I/O Ch6
		`On-time_7`	Digital I/O Ch7
	`Period_4`	`On-time_8`	Digital I/O Ch8
		`On-time_9`	Digital I/O Ch9
	`Period_5`	`On-time_10`	Digital I/O Ch10
		`On-time_11`	Digital I/O Ch11

Example settings:

Master Clock Divider	Resulting Master Clock Frequency	Generator Period	Channel Output Frequency	Note
1	64MHz	2	32MHz	Max theoretical frequency
1	64MHz	16	4MHz	Max effective frequency
1	64MHz	3200	20kHz	Typical DC motor control
20	3.2MHz	64000	50Hz	For RC Servo control
65535	976.6Hz	65535	0.0149Hz	Min frequency

Example algorithm to calculate `clock_divider`, `period`, and `on-time`, given frequency (Hz) and duty cycle (%):

```
float   frequency;
float   duty_percent;
int32u  ideal_period;
int16u  clock_divider;
int16u  actual_period
int16u  on_time;

// Example 1: 50Hz control for an RC servo motor
// ---------------------------------------------
frequency     = 50.0f;                                  // 50Hz for RC servo control
duty_percent  = 5.1f;                                   // 5.1% duty cycle
ideal_period  = 64000000 / frequency;                   // = 1280000
clock_divider = ceil((float)ideal_period / 65535.f);    // ceil(19.53) = 20
actual_period = ideal_period / clock_divider;           // = 64000
on_time       = (actual_period * duty_percent) / 100.f; // 3264

// Example 2: 20kHz control for a DC motor
// ---------------------------------------
frequency     = 20000.0f;                               // 20kHz for DC motor control
duty_percent  = 45.0f;                                  // 45% duty cycle
```

```
ideal_period  = 64000000 / frequency;                    // = 3200
clock_divider = ceil((float)ideal_period / 65535.f);     // ceil(0.0488) = 1
actual_period = ideal_period / clock_divider;            // = 3200
on_time       = (actual_period * duty_percent) / 100.f; // 1440
```

Digital Output / PWM Output Interaction

The output state of the digital pins and the PWM signals are OR-gated together. This means that if either one of them is high, then the output pin will be high. If they are both low, then the output pin will be low. Therefore it is easy to use the pin in either mode:

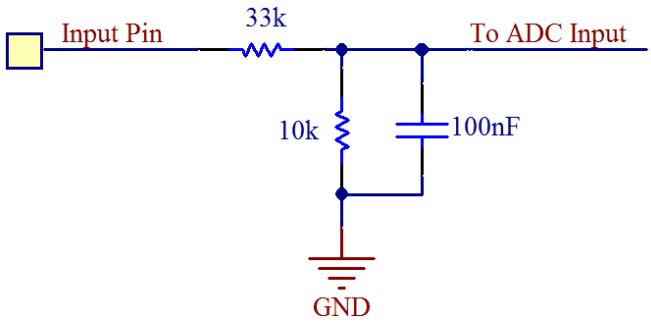
- For simple digital output, set that pin's PWM on-time to zero.
- For PWM output, set the digital output state to zero.

Analogue Inputs

Each Analogue connector provides separately regulated DC power and in total twelve analogue input channels. Each 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 twelve input channels are labelled *Ch0* to *Ch11*. The sampled 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 that 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.

General Information

Power Consumption

Number of GIO Modules	Max current draw from each 5v Digital connector	Max current draw from each 5v Analogue connector
1	70mA	100mA
2	70mA	100mA
3	60mA	90mA
4	50mA	75mA
5	40mA	60mA

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

LED Indicators

The GIO 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. There are four regulators on the GIO Module (one per analogue or digital connector)	- 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