MAKE THINGS HAPPY !

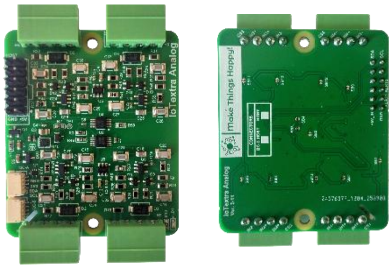
IoTextra Analog

Analog Input Module

The **IoTextra Analog** module (version 3.11) is an analog input module based on the 16-bit **ADS1115** ADC from Texas Instruments. It is compatible with most types of microcontrollers (the **I²C** interface is used for communication)

The module uses operational amplifiers and passive components with low error to reduce noise influence and ensure accuracy corresponding to the ADC resolution.

Input power: +5VDC. It includes reverse polarity protection.



The module allows measuring four differential analog signals, both voltage and current. The two ADCs installed on the module have a 16-bit resolution. The ADC type is ΔΣ (delta-sigma).

Voltage measurement ranges: 0-0.5V, 0-5V, 0-10V, ±0.5V, ±5V, ±10V.
Current measurement ranges: 0-20mA, 4-20mA, ±20mA, 0-40mA.

Measurement speed: up to 860 samples per second for the **ADS1115**.

Main Applications of the **IoTextra Analog** module:

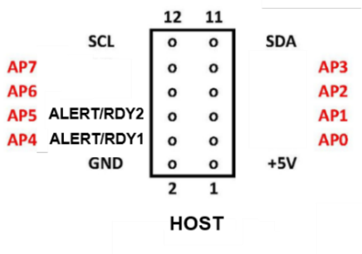
- Industrial Applications
- General-purpose voltage and current monitoring
- Transmission sensors
- Infotainment systems
- Smart Home
- Sensors
- Chargers
- Control systems

FEATURES:

- Compatibility with major known microcontrollers
- Module power supply is 5VDC
- Protection against reverse power supply polarity is included
- ADC resolution - 16 bits
- ADC type (delta-sigma)
- 4 differential analog input channels
- Voltage measurement ranges:
  0-0,5V, 0-5V, 0-10V,
  ±0.5V, ±5V, ±10V
- Current measurement ranges:
  0-20mA, 4-20mA, ±20mA, 0-40mA
- ADC measurement speed up to 860 samples per second
- **I²C** interface: 100Khz, 400Khz, 3.4Mhz
- Connection to the module via the **I²C** bus is done through **Qwiic©** connectors or through pins 11 (**SDA**) and 12 (**SCL**) of the **HOST-P12** connector
- Transient suppression and electrostatic discharge protection of signals on **Qwiic©** connectors is provided by a TVS diode assembly (ESD protection)
- The **I²C** addresses of the ADCs are changeable: the ADC for channels 1 and 2 has an address of 1001001x (which can be changed to 1001000x using **SB2** on the reverse side of the module), and the ADC for channels 3 and 4 has an address of 1001011x (which can be changed to 10010101x using **SB3** and **SB4** on the reverse side of the module)
- Programmable Gain Amplifier (PGA)
- Module size: 47x56 mm. The module has mounting holes that allow it to be installed on a base module or a Raspberry Pi Размер модуля – 47 x 56 мм.

MODULE USAGE AND HOST CONNECTOR

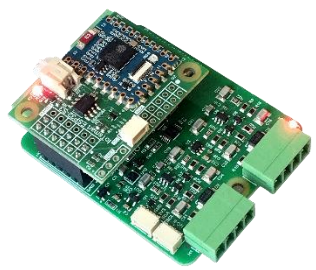
A 12-pin **HOST** connector is always installed on the **IoTextra Analog** module. The connector pins are shown in the following figure



The module can be used in the following ways:

1) ***Standalone Use***: In this mode, the input signal states are available through the **HOST** connector or via the **Qwiic©** connectors on the **I²C** bus
2) ***Smart Use***. In this mode, an **IoTsmart** module with a microcontroller is plugged into the **HOST** connector. Communication with the **IoTextra Analog** module is through the **HOST** connector. Power is drawn from the **IoTsmart** module. The figure below shows the **IoTextra Analog** module with an **IoTsmart** module:

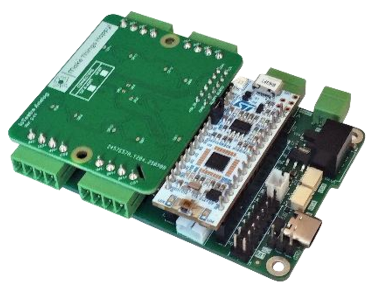
IoTextra Analog with **IoTsmart RP2350** module installed vertically



IoTextra Analog with **IoTsmart ESP32-S3** module installed horizontally

3) ***Mezzanine Use***. In this mode, the **IoTextra Analog** module is installed in a base module, and communication with it is through the **HOST-P12** connector. The figures below show the **IoTextra Analog** module installed in **IoTbase** modules:

IoTbase PICO with the **IoTextra Analog** module installed



IoTbase Nano with the **IoTextra Analog** module installed

VOLTAGE AND CURRENT MEASUREMENT CALCULATION

The measurement circuit for each channel consists of an operational amplifier, the Programmable Gain Amplifier (PGA) built into the **ADS1115**, and the 16-bit ADC (delta-sigma type) itself. The gain of the operational amplifier depends on the resistance **R**, which can be 24.95kΩ or 49,9kΩ (determined by a pair of jumpers for each channel), and is 24.95kΩ by default. For some input signal ranges, 49.9kΩ is recommended for greater accuracy.

The output voltage of the operational amplifier, depending on the measured signal range and considering the **+2.5V** reference voltage, will be as follows:

Range	Input Signal		Op-Amp Output Signal		Recommended PGA	
	I_{in}	V_{in}	V for R=24.95kΩ	V for R=49.9kΩ		
0-0,5V		0	2,5	2,5	1	1
		0,5	2,618809524	2,737619048		
±0,5V		-0,5	2,381190476	2,262380952	1	1
		0,5	2,618809524	2,737619048		
0-5V		0	2,5	2,5	1	2/3
		5	3,688095238	4,876190476		
±5V		-5	1,311904762	0,123809524	1	2/3
		5	3,688095238	4,876190476		
0-10V		0	2,5	2,5	2/3	
		10	4,876190476	7,252380952		
±10V		-10	0,123809524	-2,252380952	2/3	
		10	4,876190476	7,252380952		
0-20mA	0	0	2,5	2,5	1	2/3
	0,02	4,98	3,683342857	4,866685714		
±20mA	-0,02	-4,98	1,316657143	0,133314286	1	2/3
	0,02	4,98	3,683342857	4,866685714		
4-20mA	0,004	0,996	2,736668571	2,973337143	1	2/3
	0,02	4,98	3,683342857	4,866685714		
0-40mA	0	0	2,5	2,5	2/3	
	0,04	9,96	4,866685714	7,233371429		

The Full-Scale Range (FS) depends on the gain coefficient (PGA)

PGA SETTING	FS (V)
2/3	±6.144V(1)
1	±4.096V(1)
2	±2.048V
4	±1.024V
8	±0.512V
16	±0.256V

(1) This parameter expresses the full-scale range of the ADC scaling. In no event should more than VDD + 0.3V be applied to this device.

To determine the **measured voltage**, the following equation should be used:

$$\text{ADCNumber} = 2^{15} \times \frac{1}{FSR} \times \frac{R}{105k\Omega} \times V_{in}$$

where:

R - is the resistance, which can take the value 24.95kΩ or 49.9kΩ depending on the jumpers
FSR - is the positive full-scale range, determined by the range setting in the PGA[2:0] configuration register
V_{in} - is the input voltage

To determine the **measured current**, the following equation should be used:

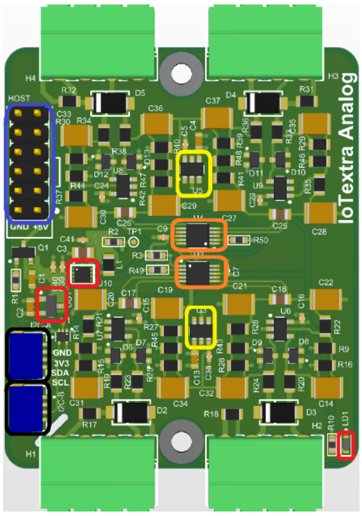
$$\text{ADCNumber} = 2^{15} \times \frac{1}{FSR} \times \frac{R}{105k\Omega} \times 249\Omega \times I_{in}$$

where:

R	-	is the resistance, which can take the value 24.95kΩ or 49.9kΩ depending on the jumpers
FSR	-	is the positive full-scale range, determined by the range setting in the PGA[2:0] configuration register
$\mathbf{I_{in}}$	-	is the input current

COMPONENT LAYOUT

The figure below shows the component placement on the **top-side** of the **IoTextra Analog** module:



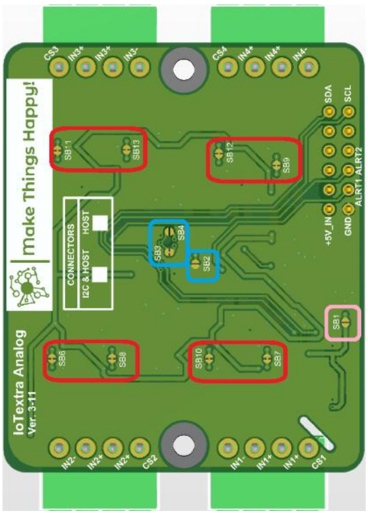
The main **HOST** connector is highlighted in blue.
The **Qwiic©** connectors are highlighted in black.
Highlighted in red are:

- The high-precision DC-DC converter **TPS62173**, used to obtain the analog +5V power
- The low-noise LDO used to obtain +3.3V
- The analog power indicator

The **ADS1115** ADCs are highlighted in orange.
The high-precision 2.5V reference voltage sources (**REF3425** type) are highlighted in yellow.

JUMPERS

The figure below shows the component placement on the **bottom-side** of the **IoTextra Analog** module:



The following jumpers are located on the **bottom-side** of the module:

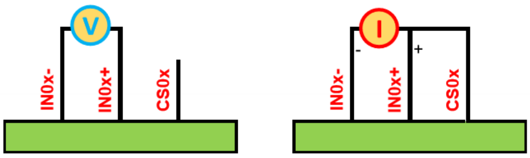
- **SB1** (highlighted in pink) - for connecting +3V3 within the module and the **Qwiic©** connectors. By default, the jumper is open, meaning there is no +3V3 power connection.
- **SB2** (highlighted in light blue) - for selecting the **I²C** interface address of the ADC for analog input channels 1 and 2 (this ADC is **U2** in the schematic). By default, this jumper is open. This means the ADC address is 1001001x. If this jumper is closed, the address of this ADC becomes 1001000x.

- **SB3** and **SB4** (highlighted in light blue) - for selecting the ADC address for analog input channels 3 and 4 (**U4** in the schematic). By default, jumper **SB3** is closed and SB4 is open. This means the address is 1001011x. If jumper **SB3** is opened and jumper **SB4** is closed, the address becomes 1001010x. Other states for jumpers **SB3** and **SB4** are not permissible.
- For selecting resistances, the jumpers are: **SB7** and **SB10** (channel 1), **SB6** and **SB8** (channel 2), **SB11** and **SB13** (channel 3), **SB9** and **SB12** (channel 4). These jumpers are highlighted in red. For each channel, both jumpers in the pair are closed by default, meaning **R** equals 24.95kΩ (see above). If both jumpers in the pair are opened, **R** for the corresponding channel becomes 49.9kΩ.

CONNECTING EXTERNAL SIGNALS

The **H1-H4** connectors on the module are used to connect external analog signals; it is recommended to insert removable 3.5mm pitch terminal blocks into them. The pin layout is marked on the **bottom-side** of the module. When **using unipolar input mode**, polarity must be observed when connecting external input signals.

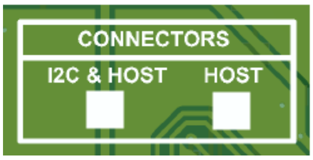
The following diagram shows the commutation for both voltage and current measurement. This commutation can be done for any channel, regardless of the commutation for other channels.



This commutation can be done for any channel, regardless of the commutation for other channels.

CONFIGURATION TABLES

Information is provided on the **bottom-side** indicating whether the **Qwiic©** connectors for **I²C** are installed



ACCESSORIES:

The following accessories may be required for using the module:

- A set of four removable terminal blocks with a 3.5mm pitch for terminal blocks **H1-H4**
- A set of two standoffs and four screws for mounting the module into the **IoTbase** series base module.
- Cable for the **Qwiic©** connector