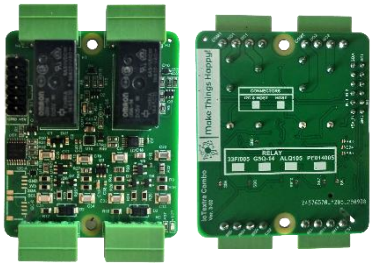
MAKE THINGS HAPPY !

IoTextra Combo

Combined Relay & Analog Input Module

The **IoTextra Combo** module (version 3.02) is a versatile solution that combines the functionality of two distinct systems: power switching via mechanical relays and high-precision analog data acquisition.
It features two **SPDT (1 Form C)** relays.
Switching Voltage: 250 VAC, 30 VDC. Contact Current Rating: 10A.
The module allows measuring two differential analog signals, both voltage and current. and two differential analog input channels driven by a 16-bit **ADS1115** delta-sigma ADC from Texas Instruments.
The module uses high-quality operational amplifiers and passive components with low error to minimize noise and ensure measurement accuracy corresponding to the ADC resolution.
Input power: +5VDC. It includes reverse polarity protection.



All digital channels have individual galvanic isolation with a dielectric strength 4000Vrms (for one minute between the coil and the contacts) and 750Vrms (for one minute between the opened contacts). Surge resistance between coil and contacts 8000V.
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 Combo** module:

- Industrial automation and PLC systems
- Smart Home: Lighting, HVAC, and power switching
- Sensor monitoring and transmission sensors
- DC motor control and infotainment systems

FEATURES:

- Compatibility with major known microcontrollers
- Module power supply is 5VDC
- Protection against reverse power supply polarity is included
- Dual-Functionality: 2 Power Relays and 2 Differential Analog Inputs
- 2 **SPDT (1 Form C)** type relays
- Switching Voltage: 250VAC/30VDC
- Contact rating (resistive):

Relay	NO	NC
Panasonic ALQ105	10A 125VAC 5A 250VAC 5A 30VDC	3A 125VAC 2A 250VAC 1A 30VDC
Omron G5Q-14	10A 125VAC 5A 250VAC 5A 30VDC	3A 125VAC 3A 250VAC 3A 30VDC
HF33F/005-ZS3	10A 125VAC 5A 250VAC 5A 30VDC	3A 250VAC 3A 30VDC
TE PE014005	5A 240VAC 5A 30VDC	

- Rated operating current is less than 80mA
- Coil resistance - 63Ω

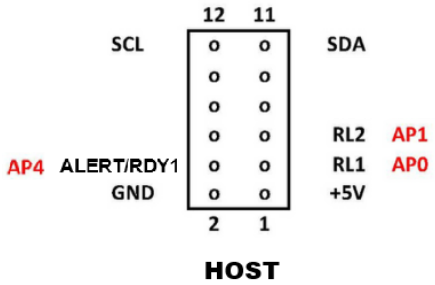
- The dielectric strength of the insulation:
  - 4000Vrms for one minute between the coil and the contacts
  - 750Vrms for one minute between the opened contacts
- Surge resistance between coil and contacts is 8000V
- When working with the module:
  - logical “1” (2.4-5V) – this turns off the relay (NC)
  - logical “0” (0-0.9V) – relay activation (NO)
- The module features LED indicators for the relay status: LED lights up when the relay is on
- The relay is controlled using **AP0-AP1** signals (**RL1-RL2**) via the **HOST** connector and/or over the **I²C** serial bus via an I/O expander
- The I/O expander used in the module is a **TCA9534** or a compatible one
- The expander's **I²C** address (**A2-A0**) is set using jumpers **JP1, JP2** and **JP3** on the bottom-side of the module:

TCA9534	0	1	0	0	A2	A1	A0	x
TCA9534A	0	1	1	1	A2	A1	A0	x

- The default address on the **I²C** bus is 0100111x (for **TCA9534**) or 0111111x (for **TCA9534A**)
- ADC resolution - 16 bits
- ADC type - ΔΣ (delta-sigma)
- 2 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
- 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)
- Programmable Gain Amplifier (PGA)
- **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** connector
- Transient suppression and electrostatic discharge protection of signals on **Qwiic©** connectors is provided by a TVS diode assembly (ESD protection)
- Module size: 47x56 mm. The module has mounting holes that allow it to be installed on a base module or a Raspberry Pi.

MODULE USAGE AND HOST CONNECTOR

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



The module can be used in the following ways:

1) ***Standalone Use***: Access signals via HOST or **Qwiic®** connectors
2) ***Smart Use***. In this mode, an **IoTsmart** module with a microcontroller is plugged into the **HOST** connector. Connection with the **IoTextra Combo** module is through the **HOST** connector. Power is drawn from the **IoTsmart** module. The figure below shows the **IoTextra Combo** module with an **IoTsmart** module:

IoTextra Combo with **IoTsmart RP2350** module

IoTextra Combo with **IoTsmart ESP32-S3** module

3) ***Mezzanine Use***. In this mode, the **IoTextra Combo** module is installed in a base module, and connection with it is through the **HOST** connector.

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
$\mathbf{V_{in}}$ - is the input voltage

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

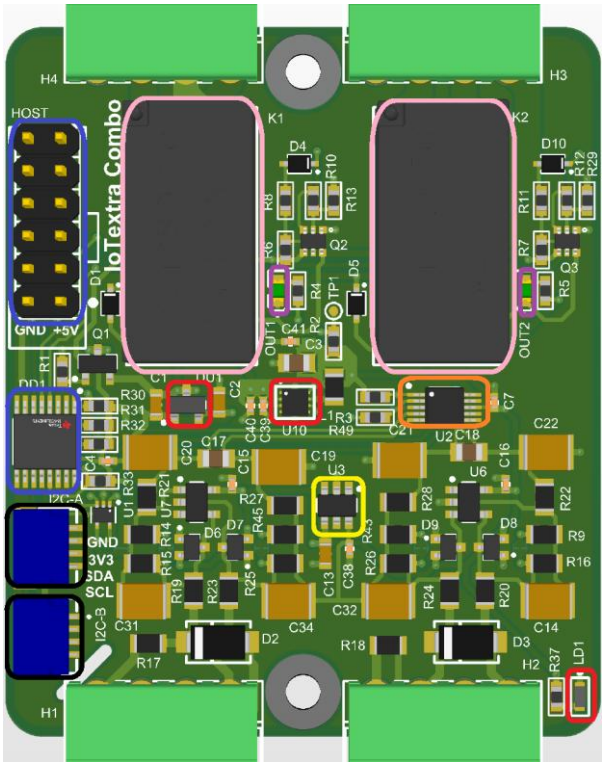
$$\text{ADCNumber} = 2^{15} \times \frac{1}{FSR} \times \frac{R}{105k\Omega} \times 249\Omega \times I_{in}$$

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 Combo** module:



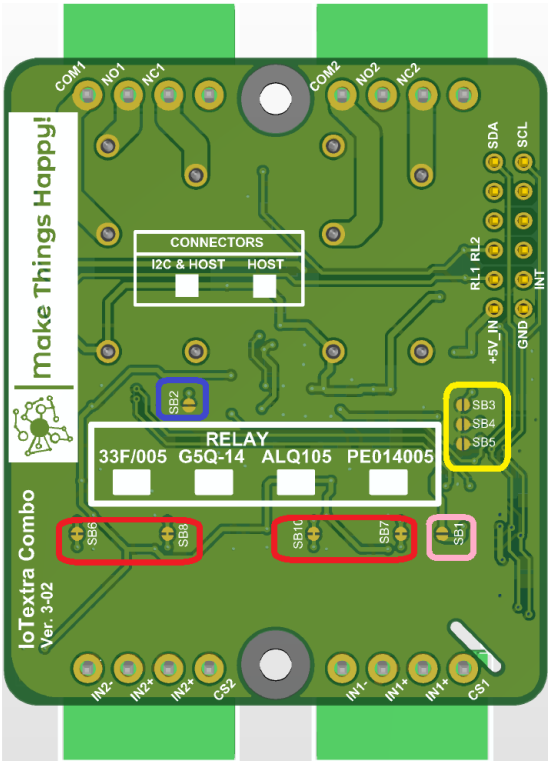
The main **HOST** connector and I/O expander used in the module is a **TCA9534** is highlighted in blue.
The **Qwiic©** connectors are highlighted in black.
Relays are highlighted in pink.
Relay status indicators are highlighted in purple.
Highlighted in red are:

- 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** ADC are highlighted in orange.
The high-precision 2.5V reference voltage source (**REF3425** type) are highlighted in yellow.

JUMPERS

The figure below shows the component placement on the **bottom-side** of the **IoTextra Combo** 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.
- The **SB3**, **SB4** and **SB5** (they are highlighted in yellow) determines the **I²C** address of the I/O expander.

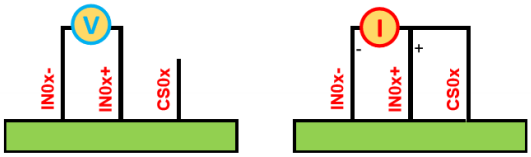
TCA9534	0	1	0	0	A2	A1	A0	x
TCA9534A	0	1	1	1	A2	A1	A0	x

  The default address on the **I²C** bus is 0100111x (for **TCA9534**) or 0111111x (for **TCA9534A**)
- For selecting resistances, the jumpers are: **SB7** and **SB10** (channel 1), **SB6** and **SB8** (channel 2). 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-H2** connectors on the module are used to connect external analog signals. The **H3-H4** connectors are for relay outputs. Connect via 3.5mm pitch removable terminal blocks. 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

The **bottom-side** also provides information about the relay model installed in the **IoTextra Combo** module.
Possible relay models:

- **HF33F/005-ZS3**
- **Omron G5Q-14**
- **Panasonic ALQ105**
- **TE PE014005**

It also provides information 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