

RASPBERRY PI I/O EXPANSION CARD

for INDUSTRIAL AUTOMATION

USER'S GUIDE VERSION 1.1

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GENERAL DESCRIPTION



The second generation of our Industrial Automation card brings to the Raspberry Pi platform all the building blocks required for Industrial Automation projects. Stackable to 8 levels, the card works with all Raspberry Pi versions, from Zero to 4.

Two of the Raspberry Pi's GPIO pins are used for I2C communication. Another pin is allocated for the interrupt handler, leaving 23 GPIO pins available for the user.

FEATURES at a glance:

- Four Optically Isolated 4-20mA Inputs
- Four 0 - 10V or 0 - $\pm 10V$ Inputs
- Four Optically Isolated Digital Inputs with status LED's
- Four 4 - 20mA Outputs
- Four 0 - 10V Outputs
- Four Optically Isolated Open Drain Outputs with status LED's (24V/4A drive)
- Four General Purpose LED's
- RS485 and CAN ports
- Real time clock with battery backup
- On-board Hardware Watchdog
- On-board Resettable Fuse
- 24VDC Power Supply

All



inputs and outputs, as well as relay contacts, use pluggable connectors which permit easy wiring access when multiple cards are stacked.

The four general purpose LED's can be associated with the analog inputs or other controlled processes.

WHAT IS IN YOUR KIT

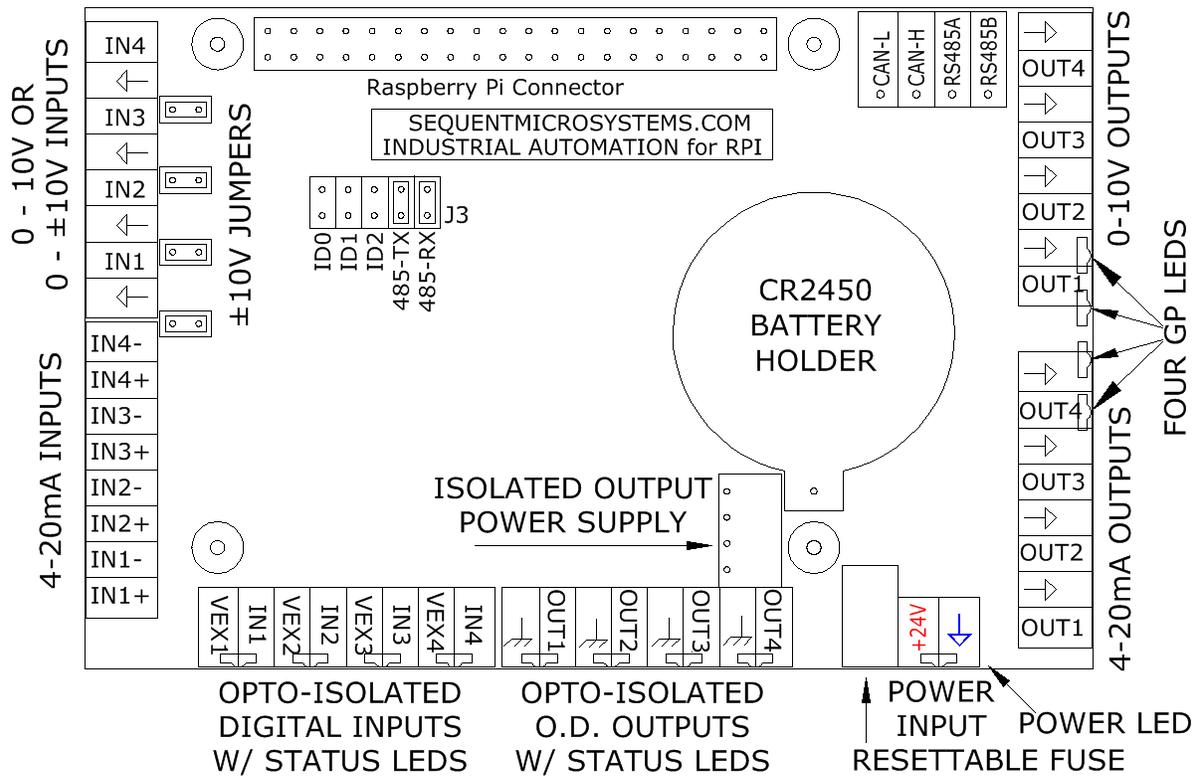
1. MEGA-IND add-on card for Raspberry Pi
2. Mounting hardware
 - a. Four M2.5x18mm male-female brass standoffs
 - b. Four M2.5x5mm brass screws
 - c. Four M2.5 brass nuts
3. Two jumpers. You do not need the jumpers when using only one MEGA-IND card. See STACK LEVEL JUMPERS section on page 6 if you plan to use multiple MEGA-IND cards.
4. Six 8-pin female mating connectors

QUICK START-UP GUIDE

1. Plug your MEGA-IND card on top of your Raspberry Pi and power up the system.
2. Enable I2C communication on Raspberry Pi using raspi-config.
3. Install the MEGA-IND software from github.com:
 - a. ~\$ `git clone https://github.com/SequentMicrosystems/megaind-rpi.git`
 - b. ~\$ `cd /home/pi/megaind-rpi`
 - c. ~/megaind-rpi\$ `sudo make install`
4. ~/megaind-rpi\$ `megaind`

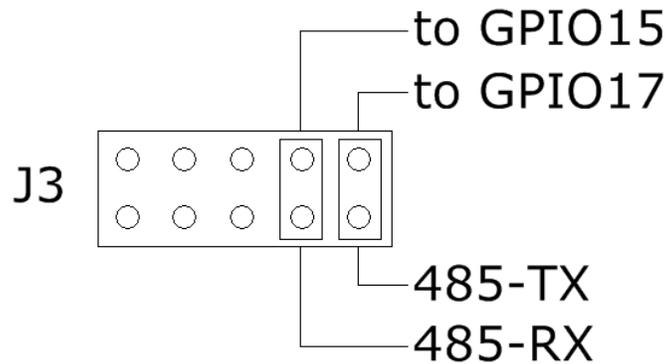
The program will respond with a list of available commands.

BOARD LAYOUT



RS-485/MODBUS COMMUNICATION

The MEGA-IND card contains a standard RS485 transceiver which can be accessed both by the local processor and by Raspberry Pi. The desired configuration is set from two bypass jumpers on configuration connector J3.



If jumpers are installed, Raspberry Pi can communicate with any device with an RS485 interface. In this configuration the MEGA-IND card is a passive bridge which implements only the hardware levels required by the RS485 protocol. To use this configuration, you need to tell the local processor to release control of the RS485 bus:

```
~$ megaind [0] wcfgmb 0 0 0 0
```

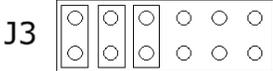
If jumpers are removed, the card operates as MODBUS slave and implements the MODBUS RTU protocol. Any MODBUS master can access all the card's inputs, and set all the outputs using standard MODBUS commands. A detailed list of commands implemented can be found on GitHub:

<https://github.com/SequentMicrosystems/megaind-rpi/blob/master/Modbus.md>

In both configurations the local processor needs to be programmed to release (jumpers installed) or control (jumpers removed) the RS485 signals. See the command line online help for further information.

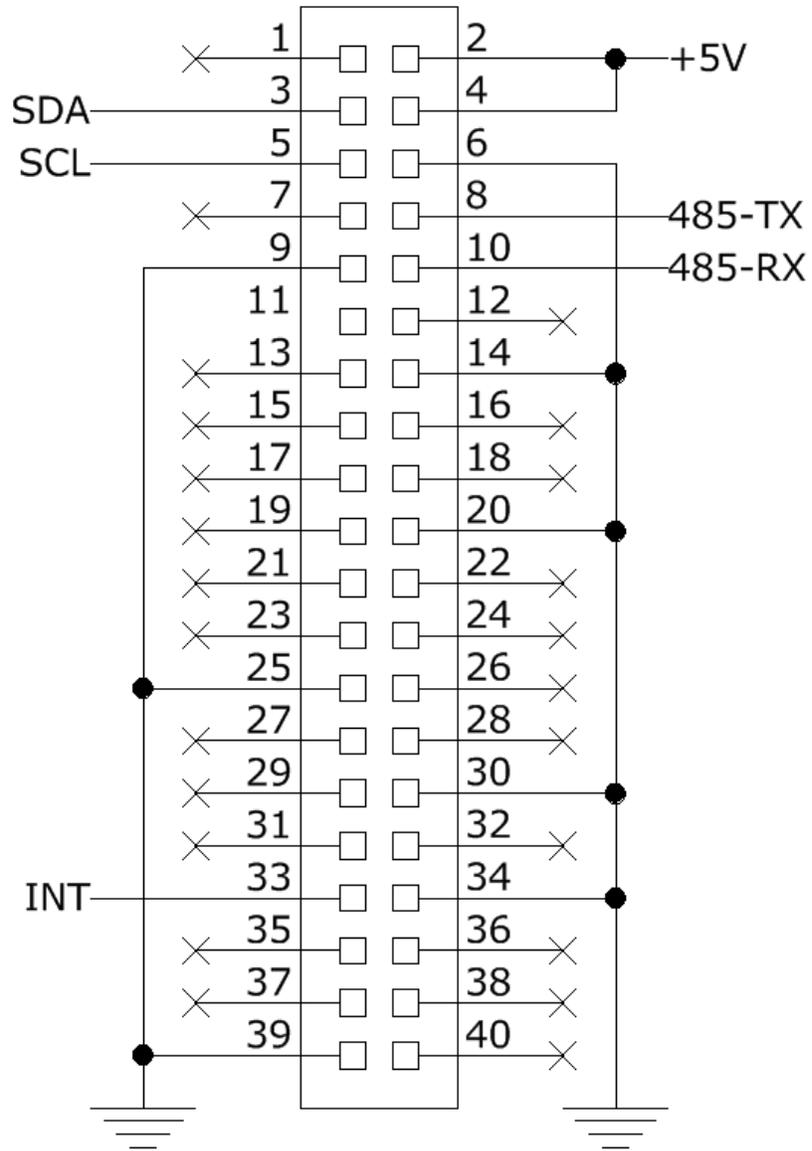
STACK LEVEL JUMPERS

The left three position of the J3 connector are used to select the stack level of the card:



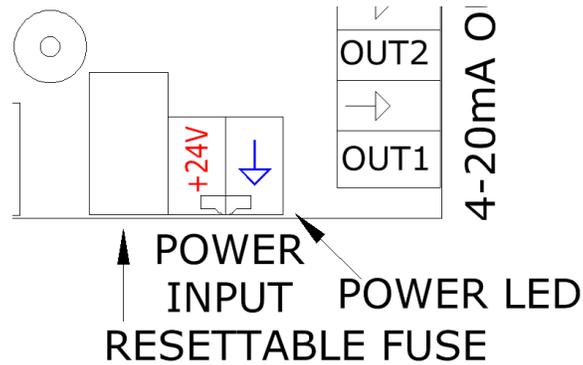
JUMPERS:								
STACK LEVEL:	0	1	2	3	4	5	6	7
I2C ADDRESS:	0x10	0x11	0x12	0x13	0x14	0x15	0x16	0x17

RASPBERRY PI HEADER



POWER REQUIREMENTS

The MEGA-IND card requires an external 24VDC regulated power supply. Power is supplied to the board through a 2 pin pluggable connector located in the lower right corner of the board. The power led is controlled by the processor and is flashing to indicate normal operation.



A local 5V regulator supplies up to 3A power to Raspberry Pi, and a 3.3V regulator powers the digital circuits. Isolated DC-DC converters are used to power the relays.

**WE RECOMMEND USING ONLY THE 24VDC POWER SUPPLY
TO POWER THE RASPBERRY PI CARD**

If multiple MEGA-IND cards are stacked on top of each other, we recommend using a single 24VDC power supply to power all the cards. The user must split the cable and run the wires to each MEGA-IND card.

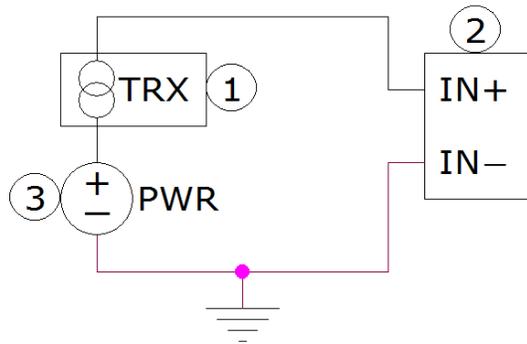
POWER CONSUMPTION:

- 50 mA @ +24V

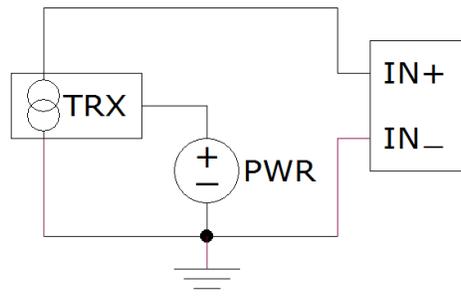
4-20mA CURRENT LOOPS

Since 4-20mA current loops are optically isolated from the system ground, they can be used with isolated on non-isolated, 2, 3 or 4 wire transmitters. In all cases you need to provide external power supply (up to 24VDC).

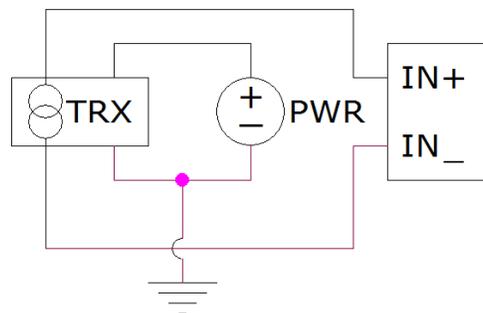
Typical configuration of the input loops:



Case 1: Two wire transmitter, shared ground.

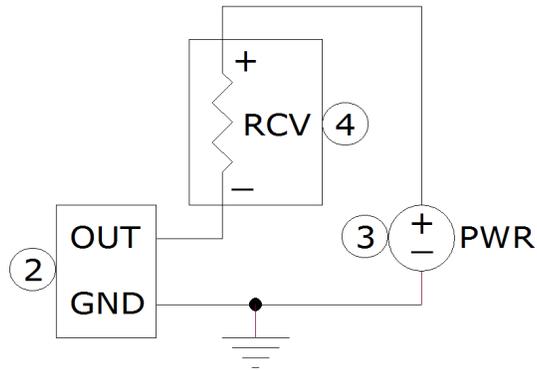


Case 2: Three wire transmitter, shared ground.



Case 3: Four wire transmitter, isolated ground.

The 4-20mA outputs are driven by Open Drain MOSFETS with a common ground. Connect your 4-20mA receiver as shown in the following diagram:



LEGEND:

- ① External 4-20mA Transmitter
- ② MEGA-IND Board
- ③ External Power Supply
- ④ External 4-20mA Receiver

0-10V Analog Inputs

The analog inputs can be jumper configured for 0 - 10V or 0 - ± 10 V range. The A/D converter has 12 bits in both configurations. Thus, the 1 bit error in the first case is 2.4mV, while in the second case is 4.9mV

One jumper per each input can be set to change the input range. Leave the jumper off for 0 - 10 range

(see Board Layout section)

HARDWARE WATCHDOG

The MEGA-IND card contains a built-in hardware watchdog which will guarantee that your mission-critical project will continue running even if Raspberry Pi software hangs up. After power up the watchdog is disabled, and becomes active after it receives the first reset.

The default timeout is 120 seconds. Once activated, if it does not receive a reset from Raspberry Pi within 2 minutes, the watchdog cuts the power and restores it after 10 seconds.

Raspberry Pi needs to issue a reset command before the timer on the watchdog expires. The command can be sent either on the I2C port , or by toggling GPIO13 (Pin 33 on the GPIO connector). The timer period after power up and the active timer period can be set from the command line. The number of resets is stored in flash and can be accessed or cleared from the command line. All the watchdog commands are described by the online help function.

ANALOG INPUTS/OUTPUTS CALIBRATION

All the analog inputs and outputs are calibrated at the factory, but firmware commands permit the user to re-calibrate the board, or to calibrate it to better precision. All inputs and outputs are calibrated in two points; select the two points as close to possible to the two ends of scale. To calibrate the inputs, the user must provide analog signals. (Example: to calibrate 4-20mA inputs, the user must provide a 4mA and 20mA current source). To calibrate the outputs, the user must issue a command to set the output to a desired value, measure the result and issue the calibration command to store the value.

The values are stored in flash and the input curve is assumed to be linear. If a mistake is made during calibration by typing the wrong command, a RESET command can be used to reset all the channels in the corresponding group to factory values. After RESET calibration can be restarted.

The board can be calibrated without a source of analog signals, by calibrating first the outputs and then routing the calibrated outputs to corresponding inputs. The following commands are available for calibration:

CALIBRATE 0-10V INPUTS:	megaind <id> cuin <channel> <value>
RESET CALIBRATION OF 0-10V INPUTS:	megaind <id> rcuin
CALIBRATE 4-20mA INPUTS:	megaind <id> ciin <channel> <value>
RESET CALIBRATION OF 4-20mA INPUTS:	megaind <id> rciin
CALIBRATE 0-10V OUTPUTS:	megaind <id> cuout <channel> <value>
STORE CALIBRATED VALUE IN FLASH:	megaind <id> alta_comanda <channel> <actual_value>
RESET CALIBRATION OF 0-10V OUTPUTS:	megaind <id> rcuout
CALIBRATE 4-20mA OUTPUTS:	megaind <id> ciout <channel> <value>
STORE CALIBRATED VALUE IN FLASH:	megaind <id> alta_comanda <channel> <value>
RESET CALIBRATION OF 4-20mA INPUTS:	megaind <id> rciout

HARDWARE SPECIFICATIONS

ON BOARD RESETTABLE FUSE: 1A

0-10V INPUTS:

- Maximum Input Voltage: 12V
- Input Impedance: 20K Ω

0-10V OUTPUTS:

- Minimum Output Load: 1K Ω

4-20mA INPUTS:

- Sample rate: 675 Hz.
- Input impedance: 150 Ω

4-20mA OUTPUTS:

- Resistive load: Maximum 1 K Ω @ 24V external voltage
- Maximum external voltage: 24V

OPEN DRAIN OUTPUTS

- Drive capability: 24V/3A

LINEARITY OVER FULL SCALE

Analog inputs are processed using 12 bit A/D converters internal to the on-board processor. The inputs are sampled at 675 Hz.

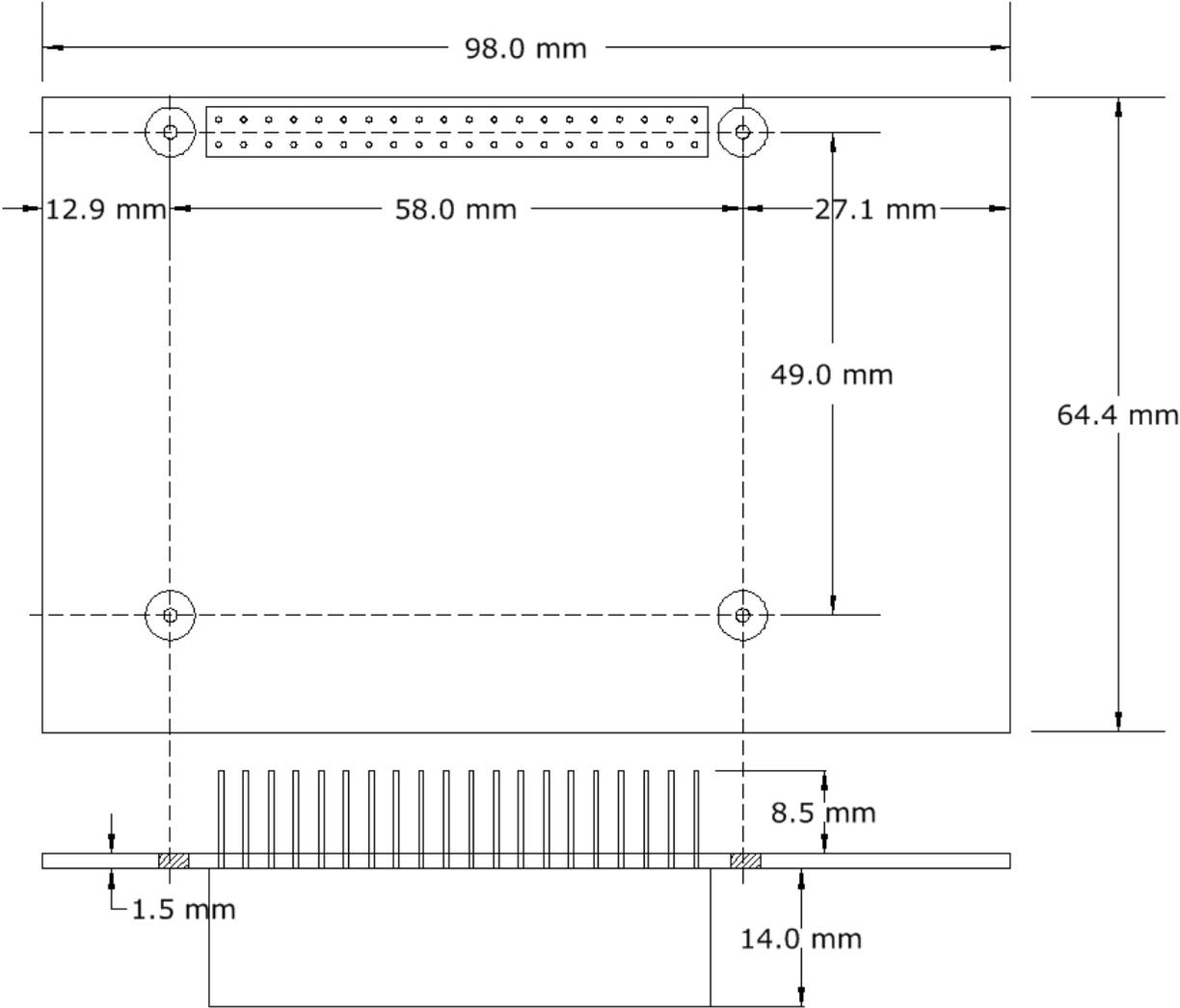
Analog outputs are PWM synthesized using 16 bit timers. PWM values range from 0 to 10,000

All inputs and outputs are calibrated at test time at the end points and values are stored in flash.

After calibration we checked the linearity over full scale and obtained the following results:

Channel	Max Error	%
4-20mA IN	32 μ A	0.2%
4-20mA OUT	10 μ A	0.06%
0-10V IN	15 μ V	0.15%
0-10V OUT	10 μ V	0.1%

MECHANICAL SPECIFICATIONS



SOFTWARE SETUP

1. Have your Raspberry Pi ready with the [latest OS](#).

2. Enable I2C communication:

```
~$ sudo raspi-config
```

1. Change User Password	Change password for default user	
2. Network Options	Configure network settings	
3. Boot Options	Configure options for start-up	
4. Localisation Options	Set up language and regional settings to match..	
5. Interfacing Options	Configure connections to peripherals	
6. Overclock	Configure overclocking for your Pi	
7. Advanced Options	Configure advanced settings	
8. Update	Update this tool to the latest version	
9. About raspi-config	Information about this configuration	
P1	Camera	Enable/Disable connection to the Raspberry Pi Camera
P2	SSH	Enable/Disable remote command line access to your Pi
P3	VNC	Enable/Disable graphical remote access to your Pi using...
P4	SPI	Enable/Disable automatic loading of SPI kernel module
P5	I2C	Enable/Disable automatic loading of I2C kernel module
P6	Serial	Enable/Disable shell and kernel messages to the serial port
P7	1-Wire	Enable/Disable one-wire interface
P8	Remote GPIO	Enable/Disable remote access to GPIO pins

3. Install the megaind software from github.com:

```
~$ git clone https://github.com/SequentMicrosystems/megaind-rpi.git
```

4.

```
~$ cd /home/pi/megaind-rpi
```

5.

```
~/megaind-rpi$ sudo make install
```

6.

```
~/megaind-rpi$ megaind
```

The program will respond with a list of available commands.

Type "**megaind -h**" for online help.

After installing the software, you can update it to the latest version with the commands:

```
~$ cd /home/pi/megaind-rpi
```

```
~/megaind-rpi$ git pull
```

```
~/megaind-rpi$ sudo make install
```