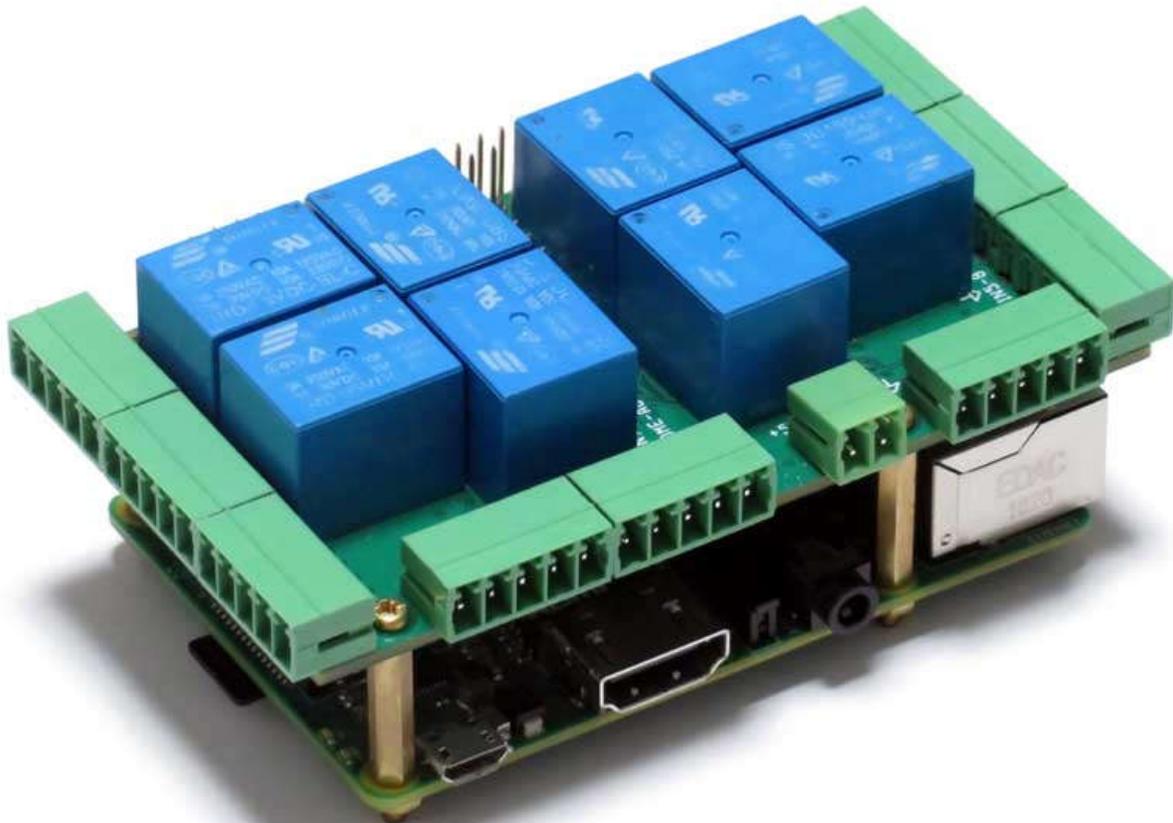


HOME AUTOMATION Card for Raspberry Pi
USER'S GUIDE VERSION 3.0

GENERAL DESCRIPTION.....	2
FEATURES.....	3
WHAT IS IN YOUR KIT.....	4
QUICK START-UP GUIDE.....	5
BOARD LAYOUT.....	6
STACK LEVEL JUMPERS.....	7
POWER REQUIREMENTS.....	8
HARDWARE WATCHDOG.....	8
GPIO INPUTS/OUTPUTS.....	9
NORMAL-OPEN RELAYS.....	10
OPTICALLY ISOLATED INPUTS.....	11
0-3.3V ANALOG INPUTS.....	12
0-10V OUTPUTS/LIGHT DIMMERS.....	14
OPEN DRAIN OUTPUTS WITH PWM.....	14
SPECIFICATIONS.....	15
MECHANICAL SPECIFICATIONS.....	16
SOFTWARE SETUP.....	17
ANALOG INPUTS/OUTPUTS CALIBRATION.....	18
HOME AUTOMATION CARD SELF TEST.....	19

GENERAL DESCRIPTION



The Home Automation Card is a stackable expansion card for Raspberry Pi. The card is compatible with all Raspberry Pi versions from Zero to 4. It provides the ideal solution for your Raspberry Pi Home Automation projects. Read temperatures in up to 8 zones with analog inputs. Control your heating and cooling system with the 8 onboard relays. Add another [8-RELAYS](#) to control your sprinklers, or [4-RELAYS](#) to control high voltage appliances. Use the 8 optically isolated digital inputs for your security system. Activate the hardware watchdog to monitor and power cycle the Raspberry Pi in case of software lockup. Control four-light systems with the four PWM open-drain outputs (you supply external power up to 24V). Control four light dimmers using 0-10V outputs.

FEATURES

- Eight relays with status LEDs and pluggable connectors
- Eight layer stackable
- Eight 12-bit A/D inputs
- Four 13-bit DAC outputs (0-10V dimmers)
- Four PWM 24V/4A open-drain outputs
- Eight optically isolated digital inputs
- Contact closure/Event counters up to 100 Hz
- Four Quadrature Encoder inputs
- 30 GPIOs (26 GPIOs from Raspberry Pi + 4 new)
- Pluggable Connectors 26-16 AWG for all ports
- On-board hardware watchdog
- On-board resettable fuse
- Reverse power supply protection
- 32-bit Processor running at 48MHz
- [Command line](#)
- [Python Library](#)
- [Node-Red Nodes](#)
- [Domoticz Plugin](#)
- [OpenPLC example integration](#)
- [Firmware Update](#)
- All mounting hardware included: brass stand-offs, screws and nuts
- Hardware self-test with loop-back cable
- Open source hardware and schematics

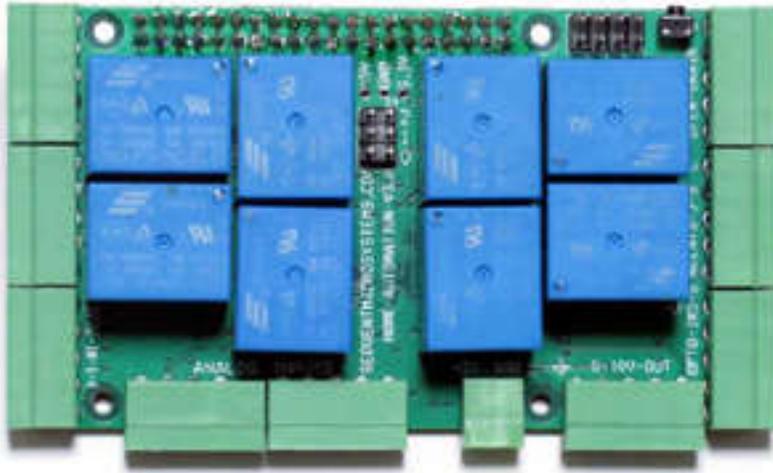
Up to eight Home Automation Cards can be stacked on top of one Raspberry Pi. Each card is equipped with a 32-bit STM processor running at 48MHz. The Home Automation Cards share a serial I2C bus using only two of the Raspberry Pi's GPIO pins to manage all eight cards. This feature leaves the remaining 24 GPIOs available for the user.

The DAC outputs can be used to control 0-10V dimmers, using the on-board 12V power supply.

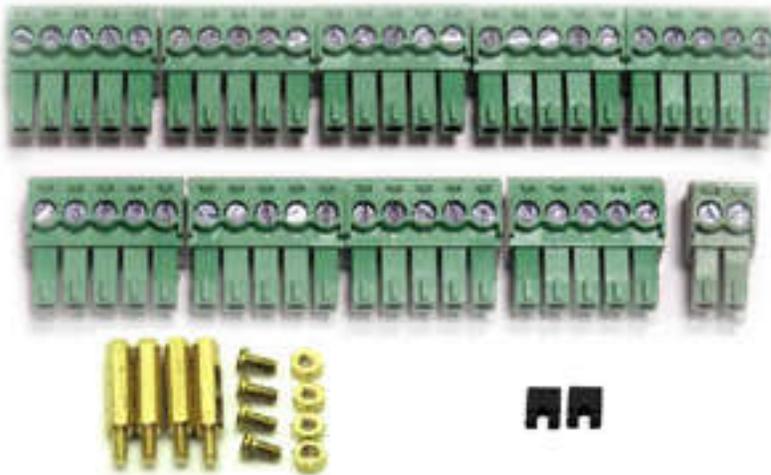
The Open Drain Outputs can be used to control analog or digital loads up to 24V and 4A.

WHAT IS IN YOUR KIT

1. Home Automation Card for Raspberry Pi



2. Mounting hardware

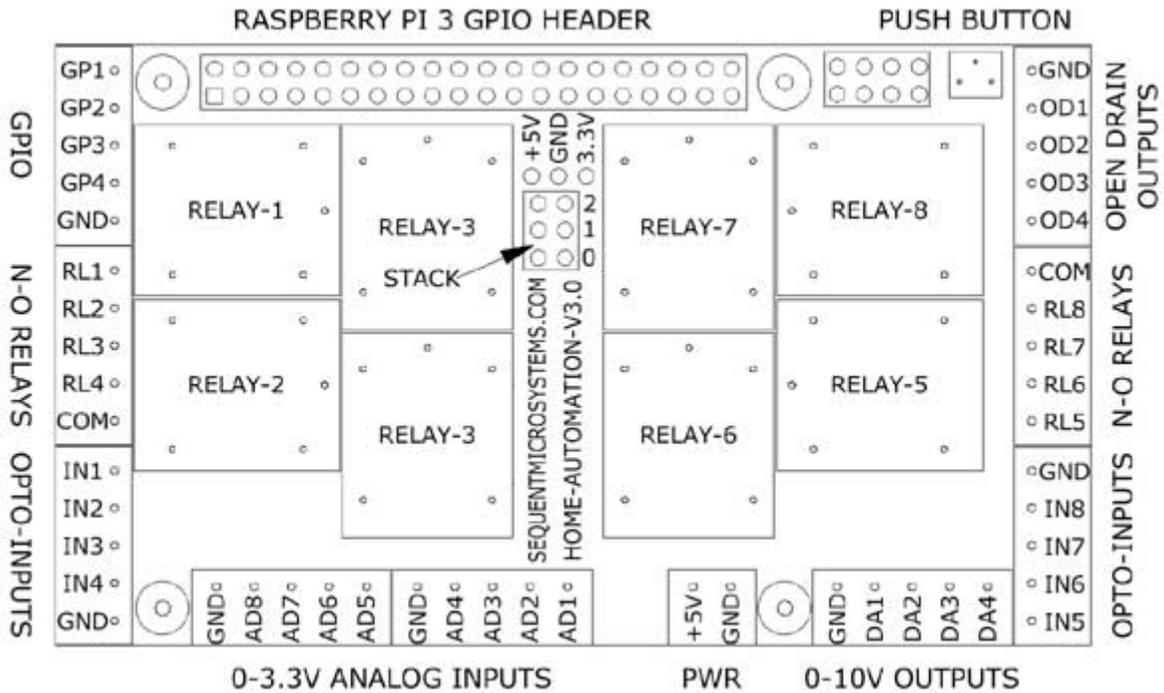


- Nine 5-pin 3.5mm pitch connector plugs for relays and I/O's
- One 2-pin 3.5mm pitch connector plug for power
- Four M2.5x18mm male-female brass standoffs
- Four M2.5x5mm brass screws
- Four M2.5 brass nuts
- Two jumpers for the stack level

QUICK START-UP GUIDE

1. Plug your Home Automation 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 software from github.com:
 - a. ~\$ `git clone https://github.com/SequentMicrosystems/ioplus-rpi.git`
 - b. ~\$ `cd /home/pi/ioplus-rpi`
 - c. ~/ioplus-rpi\$ `sudo make install`
4. ~/ioplus-rpi\$ `ioplus`
The program will respond with a list of available commands.

BOARD LAYOUT



Your Home Automation Card comes with appropriate mounting hardware. Up to eight Home Automation Cards can be stacked on top of one Raspberry Pi.

Eight LEDs (LED R1-R8) indicate the status of their respective relay. An LED is lit when the corresponding relay is energized.

POWER REQUIREMENTS

The Home Automation Card requires +5V power, supplied either from the Raspberry Pi expansion bus, or from its own power connector. The on-board relays are powered by the +5V. A local 3.3V regulator powers the rest of the circuits (see Schematics).

Raspberry Pi current consumption: 250 mA @ +5V (could be as high as 2A)

Home Automation current consumption: 50 mA @ +5V (all relays OFF)

750 mA @ +5V (all relays ON)

The power connector can handle up to 8A and is protected by a 3A resettable fuse. We recommend using a 5V regulated power supply rated at 4A or higher. The power connector has reverse polarity protection. If you apply the power incorrectly the board will not be damaged but will not work.

The Home Automation Card can be stacked up to eight levels. A multi-stack configuration can be powered from any of the cards. An eight stack needs 400 mA for electronic circuits, leaving 2.5A for relays. With some margin of error, not more than 24 relays can be ON at the same time.

If your application requires more relays to be ON at the same time, we recommend using a power supply rated 5A or higher, with a split cable to power multiple cards.

HARDWARE WATCHDOG

The Home Automation Card contains a built-in hardware watchdog which will guarantee that your mission-critical project will recover and 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.

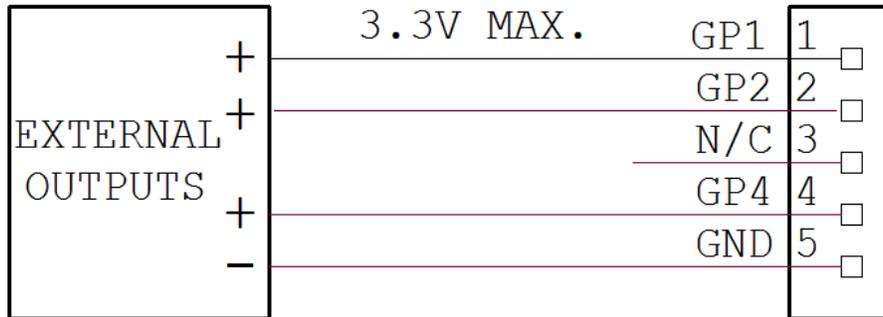
The default timeout is 120 seconds. Once activated, if it does not receive a subsequent reset from Raspberry Pi within 2 minutes, the watchdog cuts the power and restores it after 10 seconds.

Raspberry Pi needs to issue a reset command on the I2C port before the timer on the watchdog expires. The timer period after power up and the active timer period can be set from the command line. All the watchdog commands are described by the online help function.

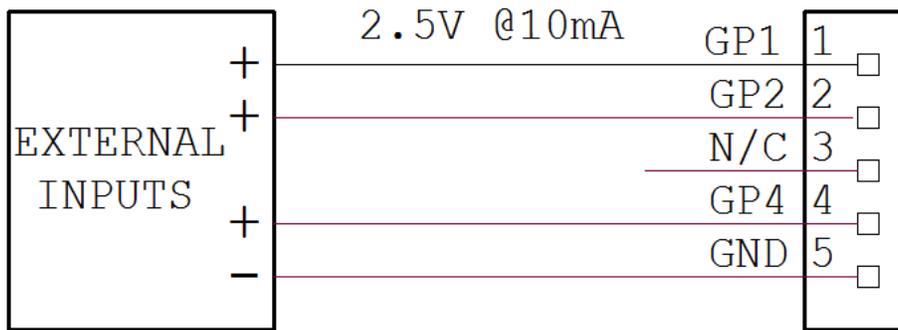
GPIO INPUTS/OUTPUTS

The GPIO outputs are connected directly to the local processor with 51 Ohms resistors. They can be used to set or read 0-3.3V digital signals.

NOTE: Due to the global semiconductor shortage, release 3.0 of the Home Automation Card uses the STM32G030C8T6 processor, which does not allow the reset pin to be used as GPIO. Thus, this version has only 3 GPIO pins, labeled GP1, GP2, and GP4.



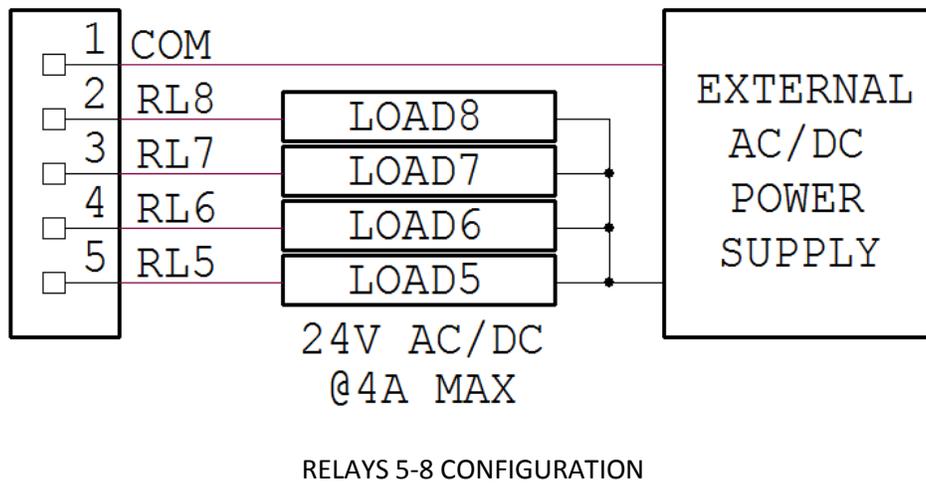
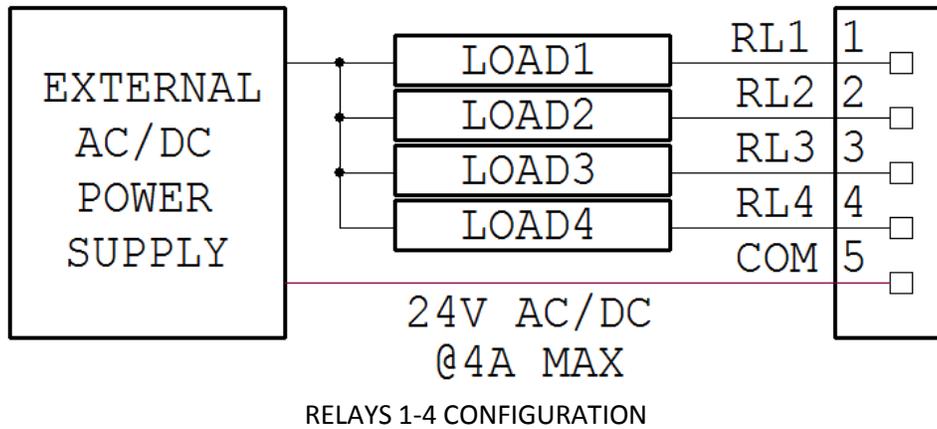
GENERAL PURPOSE INPUTS CONGIFURATION



GENERAL PURPOSE OUTPUTS CONFIGURATION

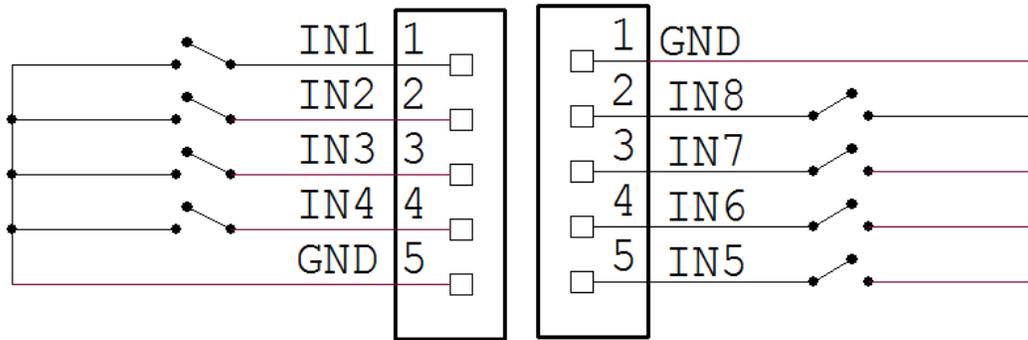
NORMAL-OPEN RELAYS

Eight on-board relays are wired in groups of four to two connectors. Each connector has one common port and four normal-open relay contacts. Due to the trace width and gap limitations, relay contacts are limited to 24VAC/DC and maximum 4A. The current limit is the sum of all loads for each 4-relay connector. Thus, the board can drive one 4A load, two 2A loads or four 1A loads.

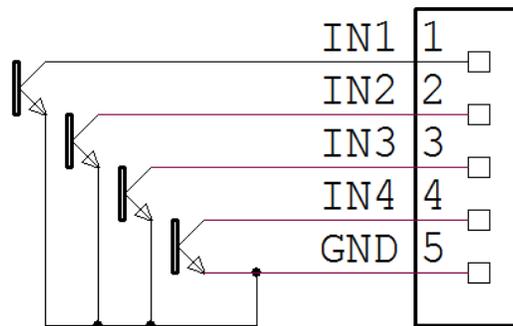


OPTICALLY ISOLATED INPUTS

The optical inputs have 1K series resistor connected to the 5V power supply. Inputs can be used to sense a contact closure, an open collector/open drain circuit or a quadrature encoder.

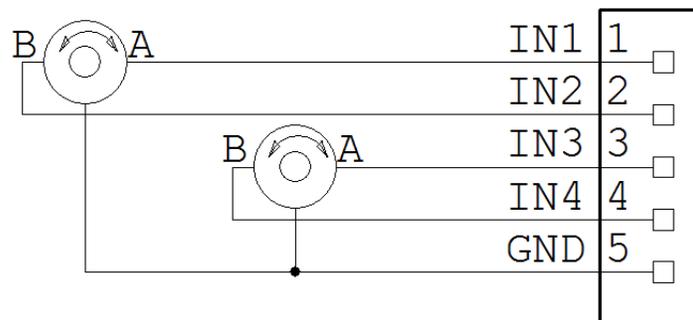


CONTACT CLOSURE CONFIGURATION



OPEN-DRAIN/OPEN-COLLECTOR CONFIGURATION

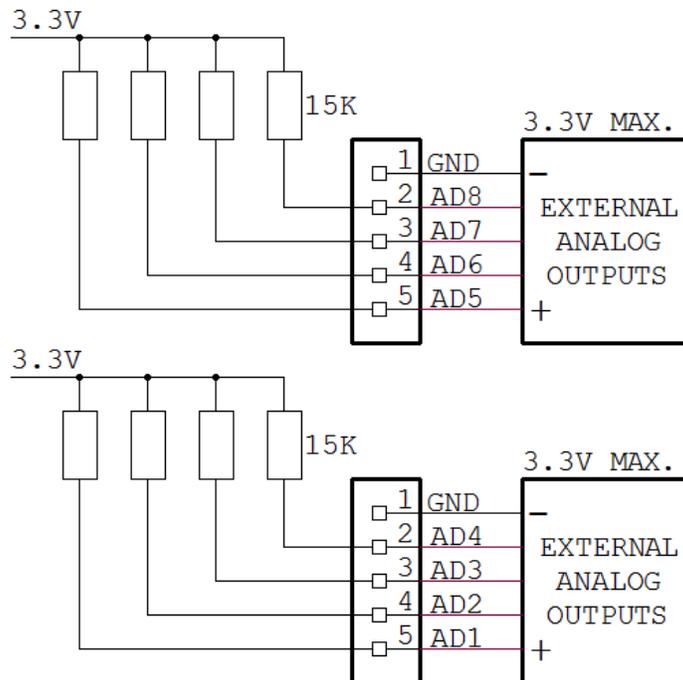
The Home Automation board can count contact closure signals on the rising or falling edge of the signal, up to 100 Hz.



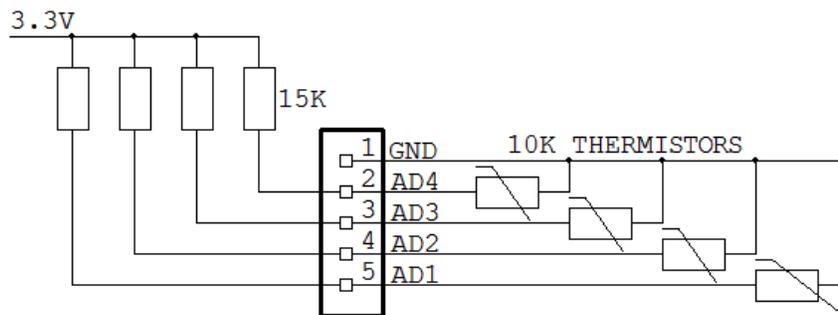
QUADRATURE ENCODER CONFIGURATION

0-3.3V ANALOG INPUTS

The Home Automation Card can measure eight analog input signals from 0 to 3.3V.



ANALOG INPUTS CONFIGURATION

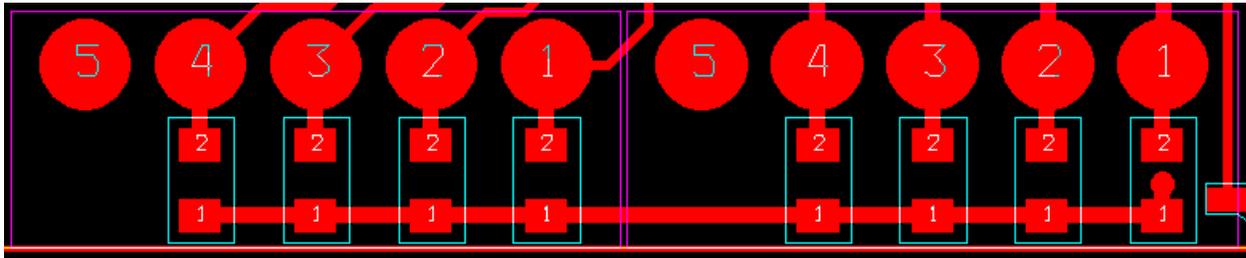


TEMPERATURE MEASUREMENT CONFIGURATION (4 OF 8 CHANNELS)

The analog inputs can be used to measure temperatures using external thermistors. The recommended thermistor value is 10Kohms.

TEMPERATURE MEASUREMENT USING LOWER RESISTANCE THERMISTORS

You can use lower value thermistors by installing an additional pull-up resistor in parallel with the on-board 15Kohms. Each input has an 0805 uninstalled resistor for this purpose, as shown in the picture bellow.



When reading analog signals, the Home Automation board responds with the signal value, in volts. You will have to compute the corresponding temperature using the table provided by the thermistor manufacturer.

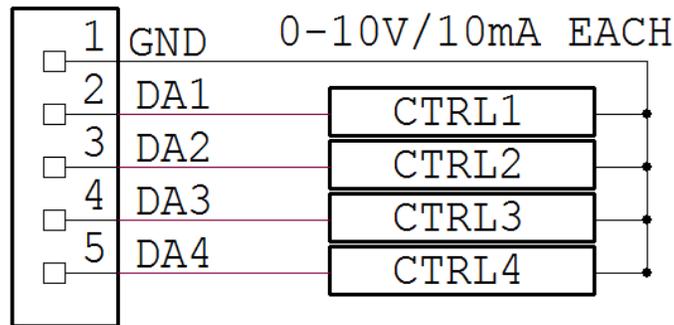
EXAMPLE

To use 1Kohm thermistor, install 2Kohm 0805 resistors on the desired channels. The pull-up resistor will be 2Kohms in parallel with 15Kohms, or 1.76Kohms. At ambient temperature, the voltage reading will be approximately half scale.

0-10V OUTPUTS/LIGHT DIMMERS

There are two accepted standards for 0-10V dimmers: the IEC standard for current sink controls, 60929 Annex E, and the ESTA E1.3 standard for current source controls. Both standards call for a maximum current of 2mA per channel. The Home Automation Card has an on-board 12V power supply and supports both standards.

The Home Automation Card can supply up to 10mA on each of the four DAC outputs. Thus, you can connect up to five Dimmer Controllers on each channel, for a total of 20 dimmable lights.

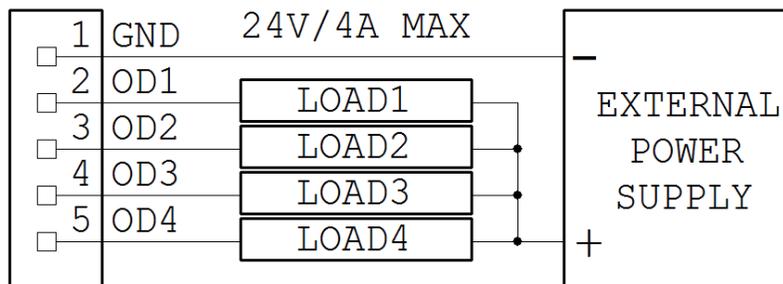


LIGHT DIMMERS CONFIGURATION

The Home Automation Card can control any four industrial control devices which requires 0-10V and less than 10mA per channel.

OPEN DRAIN OUTPUTS WITH PWM

Use this configuration to power loads up to 4A. You must provide the external power supply of up to 24V. You can use the command system to turn the outputs on and off, or proportional control using PWM. The PWM frequency is 48KHz and the fill factor can be controlled from 0% to 100%. The power supply must be able to provide the current required by the sum of the four loads.



OPEN DRAIN OUTPUTS CONFIGURATION

SPECIFICATIONS

ON BOARD RESETTABLE FUSE: 3A

OPEN DRAIN OUTPUTS:

- Maximum output current: 4A
- Maximum output voltage: 24V
- PWM frequency: 48KHz

ANALOG INPUTS:

- Maximum input voltage: 3.3V
- Input Impedance: 50 K Ω
- Resolution: 12 bits
- Sample rate: 250 samples/sec.

GPIO LINES:

- Directly from the on-board STM32F030 microprocessor under control of the software

DAC OUTPUTS:

- Resistive load: Minimum 1 K Ω
- Accuracy: $\pm 1\%$

OPTO-ISOLATED INPUTS:

- Pull-up Resistor: 1K @ 5V
- Isolation Resistance: Minimum $10^{12} \Omega$

RELAY OUTPUTS

- Maximum current/voltage: 5A/48V

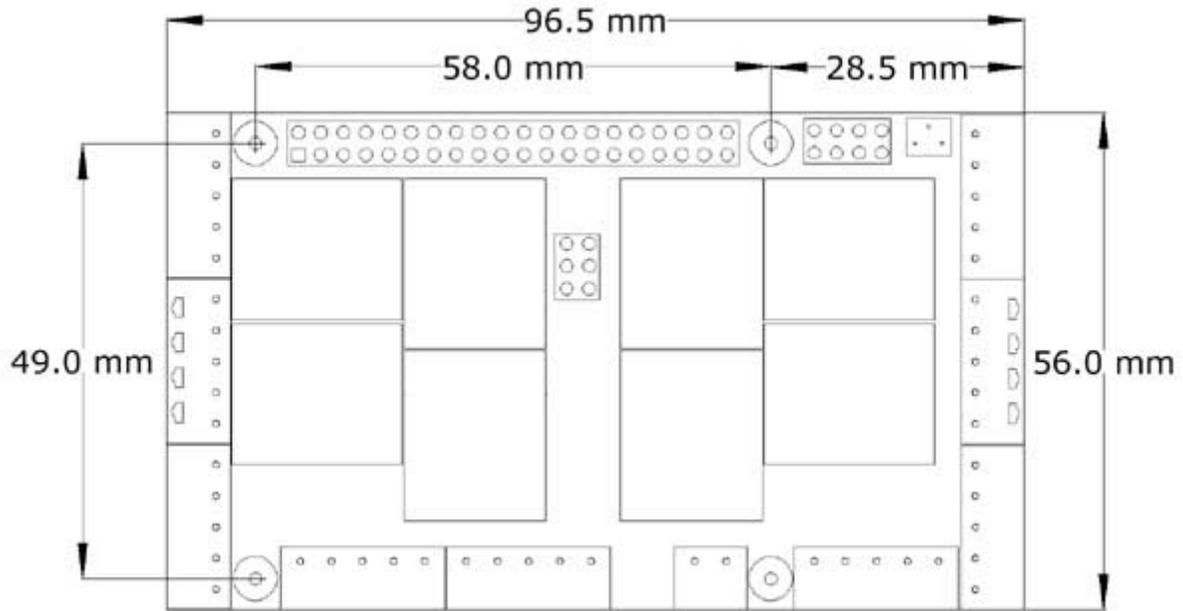
POWER CONSUMPTION:

- 50 mA @ +5V (all relays OFF)
- 750 mA @ +5V (all relays ON)

For details on connecting to the various inputs and outputs of the Home Automation the user should refer to the schematics provided here and to the data sheets for the device implementing specific the input or output (e.g. for the Opto-Isolated Inputs one would refer to the TLP-29104 data sheet.) It is the

user's responsibility to maintain input and output voltages and currents within the range specified by the manufacturer's documentation.

MECHANICAL SPECIFICATIONS



Home Automation and its compatible add-on cards can be mounted in any order. You may also intermix cards from other vendors, assuming they do not use the same I2C address (see STACK LEVEL JUMPERS section on page 6). It is recommended that you power the Raspberry Pi and the Home Automation Cards from the same supply, and that the Home Automation Card being powered is the card nearest the Raspberry Pi.

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 Home Automation software from github.com:

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

```
5. ~$ cd /home/pi/ioplus-rpi
```

```
6. ~/ioplus-rpi$ sudo make install
```

```
7. ~/ioplus-rpi$ ioplus
```

The program will respond with a list of available commands.

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

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

```
1. ~$ cd /home/pi/ioplus-rpi
```

```
2. ~/ioplus-rpi$ git pull
```

```
3. ~/ioplus-rpi$ sudo make install
```

ANALOG INPUTS/OUTPUTS CALIBRATION

All the analog inputs and outputs are calibrated at the factory within $\pm 1\%$, but firmware commands permit you to re-calibrate the board, or to calibrate it to better match your requirements. Each input is calibrated at two points and the internal software interpolates the voltage linearly between these two points. Calibration data is stored in on-board Flash ROM. For the best accuracy you should select one point close to the low end of the range of expected inputs or output and the other at the high end of the range.

To calibrate the inputs, the user must provide an accurate DC voltage. (Example: to calibrate 0-3.3V inputs, the user must provide an adjustable power supply). 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 an external voltage reference, by first calibrating the outputs and then routing the calibrated outputs to corresponding inputs. The following commands are available for calibration:

Apply 0.1V to Analog Inputs

CALIBRATE ANALOG INPUTS TO LOW LIMIT: ioplus <stack> cuin <channel> 0.1

Apply 3.2V to Analog Inputs

CALIBRATE ANALOG INPUTS TO HIGH LIMIT: ioplus <stack> cuin <channel> 3.2

RESET CALIBRATION OF ANALOG INPUTS: ioplus <stack> rcuin

SET 0-10V OUTPUTS TO LOW LIMIT: ioplus <stack> uout <channel> 0.5

CALIBRATE 0-10V LOW LIMIT: ioplus <stack> cuout <channel> <actual_value>

SET 0-10V OUTPUTS TO HIGH LIMIT: ioplus <stack> uout <channel> 9.5

CALIBRATE 0-10V HIGH LIMIT: ioplus <stack> cuout <channel> <actual_value>

RESET CALIBRATION OF 0-10V OUTPUTS: ioplus <stack> rcuout

HOME AUTOMATION CARD SELF TEST

The firmware has two commands for self testing the card. Perform these tests only after power up, with all I/O connectors removed.

SELF TESTING THE RELAYS

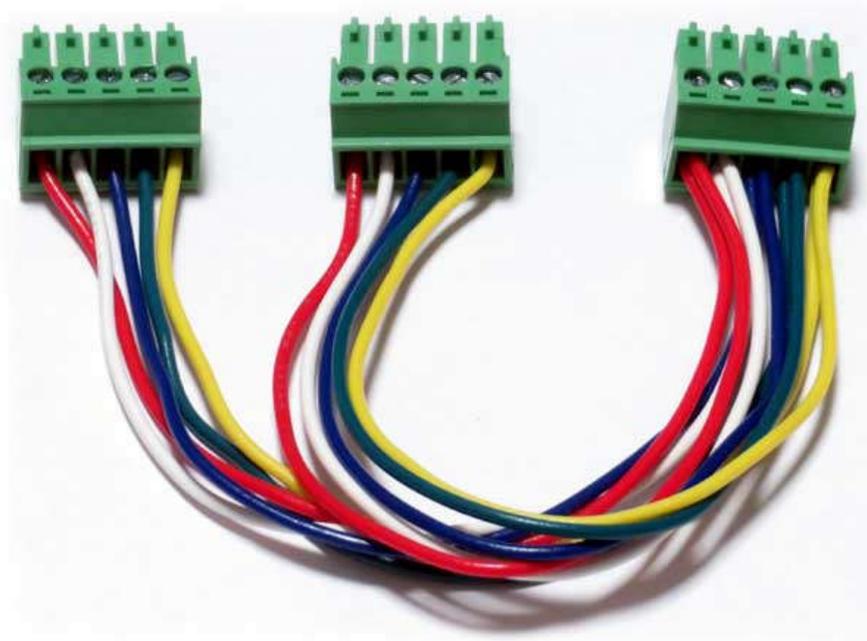
Run the command

```
ioplus <stack> reltest
```

The card will turn all the relays on, in numerical order, at 150mS interval, and then will turn them off with the same frequency. The command runs until you stop it from the keyboard. You can hear the relays closures and can watch the corresponding LED's lighting.

SELF TESTING WITH THE LOOPBACK CABLE.

All inputs, outputs and relay contacts can be tested using a 3 connector loopback cable as shown below. You can buy the cable from us, or make it yourself using 3 of the 9 connector plugs provided (assuming you do not need all of them for inputs and outputs)



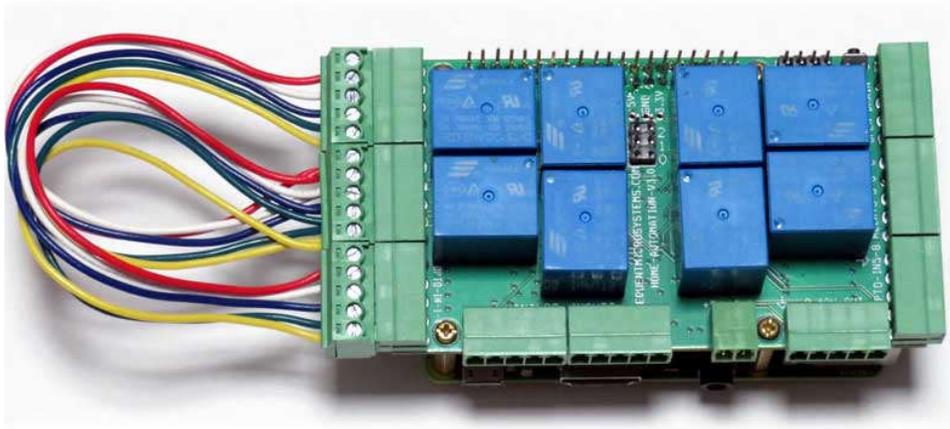
Insert the loopback card into the IO Connector of the Home Automation Card and run the command:

```
ioplus <stack> iotest <test>
```

The optional <test> parameter indicates the number of the test to be run. If not specified, the software tries to find the cable and perform the required test. The parameter can have the values 1, 2 or 3.

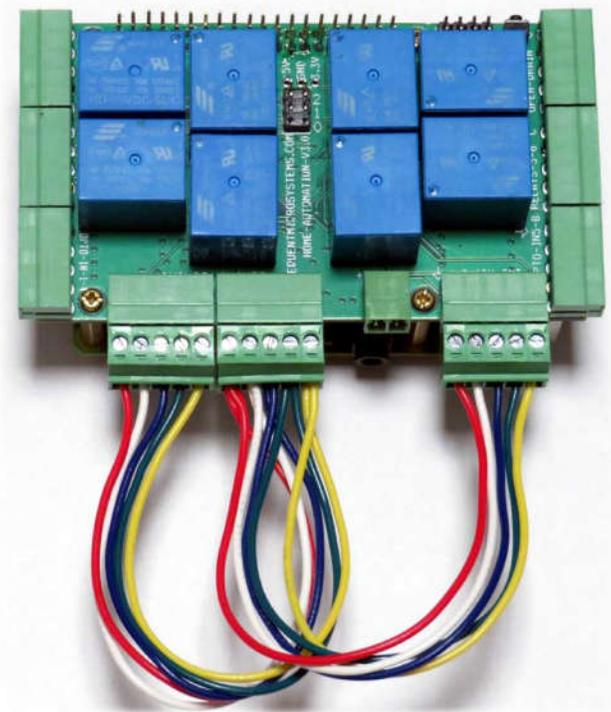
TEST 1: Self test the GPIOs and Opto-isolated Inputs 1-4 using Relays 1-4. Insert the cable as shown. Connectors can be plugged into the Home Automation Card in any order. Run the command

```
ioplus <stack> iotest 1
```



TEST 2: Self test the Analog Inputs using the Analog Outputs. Insert the cable as shown. Again, connectors can be plugged in any order. Run the command

```
ioplus <stack> iotest 2
```



TEST 3: Self test the Open Drain outputs and Opto-Inputs 5-8 using Relays 5-8. Insert the cable as shown in any order and run the command

ioplus <stack> iotest 3

