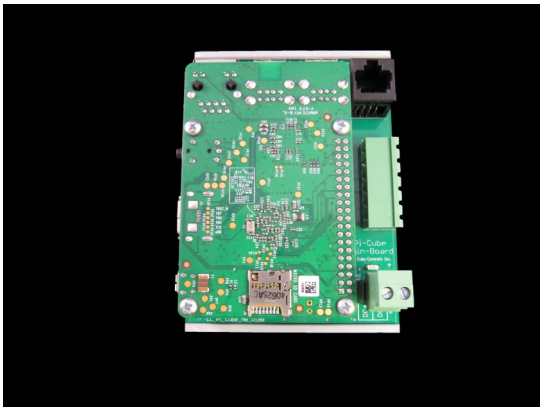
Cube-Controls™

Pi Cubes Main Board Manual



Pi Cubes is DIY modular automation system for Home/HVAC Automation .
It is based on the Raspberry Pi B+/A+ as well Raspberry Pi 2. It supports up to 24 I/O Points and up to 4 communication thermostats.

Modular design provides easy way to mix and match I/O modules to create your own custom automation solution to control your Furnace, Humidifier , Zone Valves/Dampers and everything else you would like to control in your home.

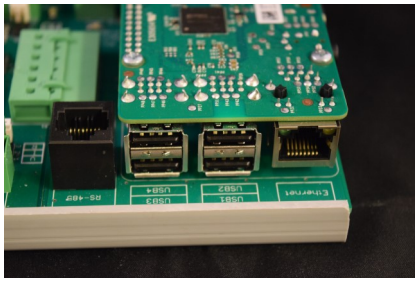
Raspberry Pi provides wide range of programming options for controller, from Python, Node JS, C/ C++ and all kind of existing control frameworks.

Features

Basic component of system is the Pi-Cubes Main Board, that board is motherboard of the system, Raspberry PI B+/2 is mounted on this board and safely attached on spacers with screws.

Main features are:

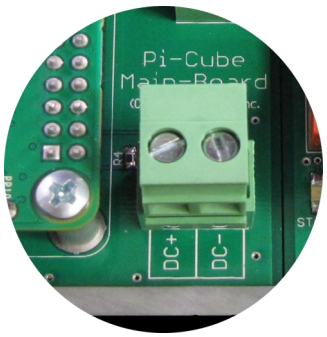
- Integrated 24VDC power supply.
- Integrated RTC with backup rechargeable battery
- Super Capacitor Backup to allow Safe Linux shutdown.
- RJ45 communication jack for thermostats, it supports RS485 communication and power to thermostats trough one cable.
- Extension port for I/O modules.



Technical Specifications

Power supply:	24V DC, MAX: 1.5A
Real Time Clock:	Maxim DS1337 I2C RTC on I2C-0
RTC Battery:	7mAh Lithium Rechargeable battery provides 3 month of backup time.
Super Capacitor Backup:	Two 22F Super Capacitors provide 40 seconds of backup time on 0.5A.
RJ45 Communication Port:	Support up to 4 communication thermostats, provides RS485 communication and power.
Extension Modules Port:	Support up to 6 I/O Modules , provides power and communication with modules on I2C-1.
Dimension:	W 76mm (3”) x H 101 mm (4”) x D 25mm (1”)
Mounting:	Modified Tyco PVC PCB Track
CC Part Number:	CC-PI-CUBES-MB

Power Supply



Main board supports 24VDC power supply source. Integral 5VDC and 15VDC switching power supplies provide correct 5VDC power supply to Raspberry Pi and 5VDC/15VDC supply to the I/O Modules.

Power Supply Specification :

- Input 24V DC , MAX: 1.5A
- Integral 5V DC Power Supply , MAX Output: 1.2A
- Integral 15VDC Power Supply , MAX Output: 2.9A

Real Time Clock

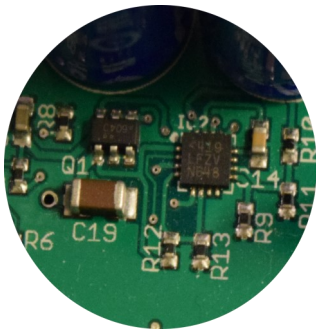
Real Time Clock is provided by Maxim DS1337 IC on the Raspberry PI I2C-0 bus. 7mAh Rechargeable Lithium battery provides up to 3 month of backup time.

Please follow next tutorials to setup RTC on Raspberry Pi:

http://www.cube-controls.com/blog/how-to-enable-i2c-on-raspberry-pi

http://www.cube-controls.com/blog/enable-the-pi-cube-main-board-integrated-rtc-on-raspberry-piraspbian

Super Capacitor Backup



Super Capacitor Backup is based on the Linear LTC3226 IC and two 22F super capacitors.
Raspberry Pi receives signal trough GPIO4 that can be used to start safe shutdown sequence.
Once Raspberry Pi is in the shutdown mode and power is restored , first I/O module connected to Main Board will use SCL1 to wake up Raspberry pi from the shutdown mode. Only RPi is powered by backup power, use table to determine maximum possible backup time based on Raspberry Pi load.

Current	Backup Time
0.2 A	99 seconds
0.5 A	40 seconds
0.8 A	24 seconds
1.0 A	20 seconds

Power Mode Jumper

Main board has jumper JP1 that is used to setup board in one of two power modes:

- Normal Mode — In this mode Raspberry Pi is directly powered from power supply.
- Backup Mode — In this mode Raspberry Pi is powered trough Super Capacitor Backup Power Supply. Safe shutdown program should be enabled before changing board to this mode, as well there should be program running communication with the I/O modules

Note : This jumper should be only changed when Raspberry Pi board is powered off.

Hardware Watchdog Relay

Hardware Watchdog Relay is only operational in the Backup Mode.

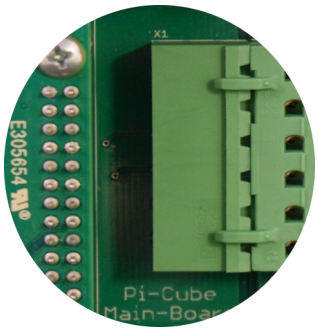
Function of relay is to do hard reset of Raspberry Pi if first I/O boards does not communicate with Raspberry Pi in period 3 minutes.

RJ45 Communication Port

RJ45 Communication Port supports up to 4 Communication thermostats. RS485 Communication and Power is supplied trough the CAT5 cable to thermostats. RS485 is provided by Maxim MAX13487 with Auto Direction. There is an integrated End of Line Resistor and biasing on the board, as well overload and ESD protection.

If not used for Modbus RTU communication to communication thermostats it may be used for another RS485 based communication protocol.

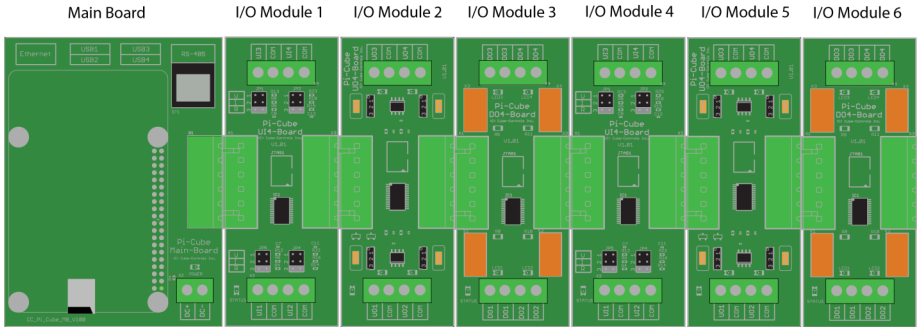
Extension Module Port



Pi Cubes Main Board with Raspberry Pi is using I2C to communicate with the I/O Modules.

I/O Modules are daisy chain with I2C and they are self -addressing, just communication with first I/O module with I2C it will provide access to all 6 IO modules.

I2C communication is same like communication to the EEPROM I2C memory. I2C Slave address for the I/O modules is 1C hexadecimal and I2C-1 is used on the Raspberry Pi.

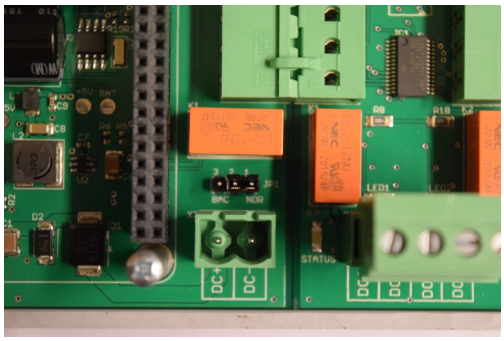


Mounting

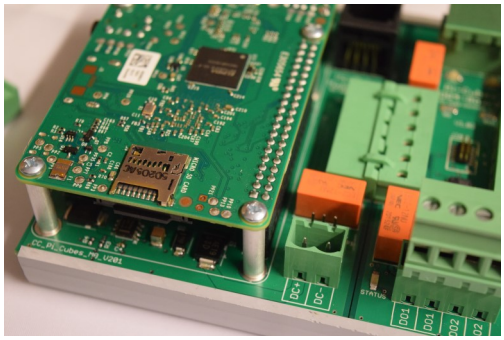
Mounting of the Main Board and I/O modules is done by modified Tyco PVC PCB Track.
Track is cut to match size and number of I/O modules.

Quick Raspberry Pi Installation

1. Remove Jumper JP1 before installing Raspberry Pi.

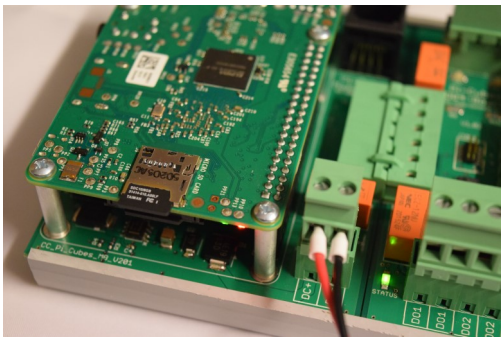


2. Install Raspberry Pi and fixed it with screws, install jumper JP1 in to Normal position.

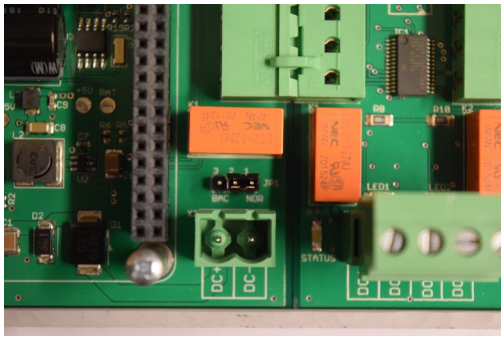


3. Place SD Card in to Raspberry Pi and power it up.

Use only regulated 24VDC Power supply.



Power Mode Jumper Installation Guide



To move jumper from the Normal to Backup position follow next steps.

1. **Shutdown script should be installed and communication to I/O modules should be established from running program.**
2. **Remove Power from the Main Board.**
3. **Move jumper to the Backup position, in this moment Raspberry Pi may start booting up on the backup owner.**
4. **Connect Main board to the DC Power Supply.**

To move jumper from the Backup to Normal position follow next steps:

1. **Shutdown Raspberry Pi using command "sudo shutdown –h now" or removing power and waiting for shutdown script to shutdown Raspberry Pi.**
2. **Soon as the RPi is safe shutdown, remove power supply if not removed already.**
3. **Move jumper to Normal position.**
4. **Connect Main board to the DC Power Supply.**

I2C I/O Modules Memory Map

Read/Write Memory Locations (0-47)

First 48 locations in the memory are used as read/write locations,
function of them is to control UO/DO Boards and to configure UI Boards.

Address can be calculated using next formula and the tables:

Module Offset = (ModuleNo-1) * 8

Module number is equal to I/O the module position counting from the left to the right.

Address	PI-Cube UI4 Function	PI-Cube UO4 Function	PI-Cube DO4 Function
0 + Module Offset	Universal Input 1 Type	Universal Output 1 Type	Digital Output 1 Value
1 + Module Offset	N/A	Universal Output 1 Value	N/A
2 + Module Offset	Universal Input 2 Type	Universal Output 2 Type	Digital Output 2 Value
3 + Module Offset	N/A	Universal Output 2 Value	N/A
4 + Module Offset	Universal Input 3 Type	Universal Output 3 Type	Digital Output 3 Value
5 + Module Offset	N/A	Universal Output 3 Value	N/A
6 + Module Offset	Universal Input 4 Type	Universal Output 4 Type	Digital Output 4 Value
7 + Module Offset	N/A	Universal Output 4 Value	N/A

Table 1. Address calculation

Universal Input Type	0 – Resistance Input 0 -350K 1 – Digital Input 2 – Voltage 0-10V/Current 0-20mA Input 3 – 10K Type II Thermistor Input 4 – Pulse Input 1Hz
Universal Output Type	0 – Universal Output as Digital Output 0/12VDC 1 – Universal Output as Modulation Output 0-10V 2 to 255 – Period in Seconds for Universal Output as PWM Output.
Universal Output Value	0 – Digital Output Off 1 – Digital Output On 0% to 100% - Percentage value for Modulation or duty cycle for PWM Mode.
Digital Output Value	0 – Digital Output Off 1 – Digital Output On

Table 2. Configuration Functions

I2C I/O Modules Memory Map

Read Memory Location (48-143)

Read locations in memory are for Universal Inputs I/O modules, memory locations are calculated as per table below:

Module Offset = 48 + (ModuleNo-1) * 16

Module number is equal to the I/O module position counting from left to right.

Address	Function
0 + Module Offset	Universal Input 1 Byte 1
1 + Module Offset	Universal Input 1 Byte 2
2 + Module Offset	Universal Input 1 Byte 3
3 + Module Offset	Universal Input 1 Byte 4
4 + Module Offset	Universal Input 2 Byte 1
5 + Module Offset	Universal Input 2 Byte 2
6 + Module Offset	Universal Input 2 Byte 3
7 + Module Offset	Universal Input 2 Byte 4
8 + Module Offset	Universal Input 3 Byte 1
9 + Module Offset	Universal Input 3 Byte 2
10 + Module Offset	Universal Input 3 Byte 3
11 + Module Offset	Universal Input 3 Byte 4
12 + Module Offset	Universal Input 4 Byte 1
13 + Module Offset	Universal Input 4 Byte 2
14 + Module Offset	Universal Input 4 Byte 3
15 + Module Offset	Universal Input 4 Byte 4

Table 3. Address calculation

Universal Input Function	Format	Unit	Scale
Resistance Input	Signed 32 bit integer	Resistance 0 -350000R	1
Digital Input	Signed 32 bit integer	Digital Input 0..1	1
Voltage/Current Input	Signed 32 bit integer	Voltage/Current 0..100%	0.1
10K TII Thermistor Input	Signed 32 bit integer	Temperature -40C to 140C	0.01
Pulse Input	Unsigned 32 bit integer	Pulse Count	1

Table 4. Universal Input Function Formats

For reference use samples on Github : https://github.com/Cube-Controls/

Pi-Cubes Installation Terms & Conditions

Pi-Cubes is FCC 15/ICES-003 Class A product. In a domestic environment this product may cause radio interference, in which case the user may be required to take adequate measures:

- **Use all grounded shield cables.**
- **Install Pi-Cubes Main Board in to grounded control panel.**
- **Use adequate Ferrites on the cables if needed.**

Pi-Cubes will be subassemblies of your final product and you have full and exclusive responsibility to assure safety and compliance of your product based on the Pi-Cubes with all Federal, State and local regulatory requirements and other applicable regulatory requirements.

NO LIABILITY

TO THE MAXIMUM EXTENT PERMITTED UNDER APPLICABLE LAW, CUBE-CONTROLS INC., SHALL NOT BE LIABLE TO YOU, OR ANY THIRD PARTY, FOR ANY INDIRECT, EXEMPLARY, SPECIAL, CONSEQUENTIAL OR INCIDENTAL DAMAGES OF ANY KIND ARISING IN ANY WAY OUT OF USE OF THE PRODUCTS, INCLUDING, WITHOUT LIMITATION, LOSS OF PROFITS, REVENUES OR DATA, OR COSTS OF REPLACEMENT GOODS, EVEN IF CUBE-CONTROLS INC. HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES AND NOTWITHSTANDING THE FAILURE OF ANY LIMITED REMEDY OF ITS ESSENTIAL PURPOSE.

Limited Product Warranty

We warrant Cube-Controls Products will be free from manufacturing defects for a period of thirty (30) days following the date of delivery to you. We will replace, repair or credit you for any confirmed defective product at our option. Please contact info@cube-controls.com with any issues.