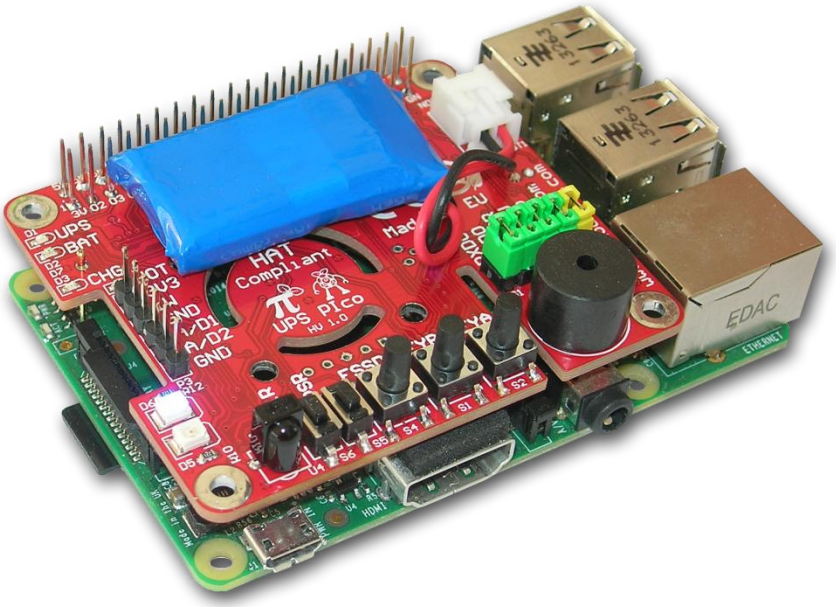
UPS PIco

Uninterruptible Power Supply

with Peripherals and I²C control Interface

for use with

Raspberry Pi® B+, A+, B, and A



HAT Compliant

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Bootloader and File Safe Shutdown Functionality

Version 1.0

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Intelligent Modules for your Raspberry Pi®

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Table of Figures

Credits

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System Overview

Introduction

The **UPS PIco** is an advanced uninterruptible power supply for the Raspberry Pi® that adds a wealth of innovative power back-up functionality and development features to the innovative microcomputer!

The standard **UPS PIco** is equipped with a 300mAh LiPO battery specially designed to enable safe shutdown during a power cut. Additionally, this can be easily upgraded to the extended 3000mAh version, which enables prolonged use of a Raspberry Pi for **up to 8 hours** without a power supply connected!

The **UPS PIco** features an embedded measurement system that continuously checks the powering voltage of the Raspberry Pi®. When the cable power on the Raspberry Pi® is absent, insufficient, or the device detects a power failure, the **UPS PIco** automatically switches to the unit's battery source. The module then continues to check the voltage on the Pi and switches automatically back to the regular cable supply when power becomes once again available.

The **UPS PIco** is powered and the battery pack intelligently charged via the GPIO pins on the Raspberry Pi®, so no additional cabling or power supply is required.

The **UPS PIco** is designed to be 100% compliant with HAT standards for the Raspberry Pi® B+ and A+, and is mechanically compatible with the original Raspberry Pi® models A and B when an extension header is used. In addition to this, because the **UPS PIco** requires no external powering and fits within the footprint of the Raspberry Pi®, it is compatible with most cases.

The **UPS PIco** can also be equipped with an optional **Infra-Red Receiver** which is routed directly to GPIO18 via the PCB. This opens the door for remote operation of the Raspberry Pi®and **UPS PIco**!

Finally, the **UPS PIco** features an implemented Automatic Temperature Control **PWM fan controller**, and can be equipped with a micro fan kit, which enables the use of the Raspberry Pi® in extreme conditions including very high temperature environments.

Applications

UPS PIco is equipped with plenty of features which make it an extremely useful tool for Raspberry Pi® project development. It not only provides powering continuity, but also offers extra user programmable LEDs, sensors, buttons and I/O's. The unit also features a dedicated **10-bit analogue to digital converter** with two channels making it the perfect board for remote and unmanned sensor deployment. These extra features result in the **UPS PIco** being a superior all-in-one device, perfect for many innovative projects and embedded applications.

Features

The list of features of the **UPS PIco** is as follows:

- Raspberry Pi B+ **HAT Compliant**
- **Plug and Play**
- **Smart Uninterruptible Power Supply (UPS)**
- **Integrated LiPO Battery** (8-10 Minutes of Power Back-Up)
- **Intelligent Automatic Charger**
- **No Additional External Power Required**
- **Optional 3000 mAh** Battery for 8 Hours Run-Time (Not Included)
- **5V 2A Power Backup (Peak Output 5V 3A)**
- Integrated Software Simulated **Real Time Clock (RTC)** with Battery Back-Up
- **File Safe Shutdown** Functionality
- Raspberry Pi B+ **Activity Pin**
- **PWM fan control** (Fan Not Included)
- **2 User Defined LEDs**
- **2 User Defined Buttons**
- **Integrated Buzzer** for UPS and User Applications
- **Status Monitoring** - Powering Voltage, UPS Battery Voltage and Temperature
- **I2C PICo Interface** for Control and Monitoring
- **RS232 Raspberry Pi** Interface for Control and Monitoring
- **XTEA Based** Cryptography User Software Protection
- 2 Level **Watch-dog Functionality** with **FSSD and Hardware Reset**
- **Raspberry Pi B+ Hardware Reset Button via Spring Test Pin** (Not Included)
- **Jumpers for Raspberry Pi B+ Pin** Functionality Selection
- **Stackable Header** for Add-On Boards
- **Boot Loader** for Live Firmware Update
- Compatible with **Intelligent IR Remote Power ON/OFF (PowerMyPi)**
- **Integrated ESD-Protected 2 Channel A/D 10 Bit Converters 0-5.2V**
- **Integrated ESD-Protected 1-Wire Interface**
- **Labeled J8 Raspberry Pi B+ GPIO Pins** for Easy Plug & Play
- **Infra Red Receiver** Sensor Interface (IR Not Included)
- **Upgradable** with **PIco Add-on Boards**
- **Fits Inside Most Existing Cases**

UPS PIco Bootloader

UPS PIco is equipped with bootloader functionality. The bootloader is a functionality that allows the user to keep the firmware up-to-date by downloading newer versions from the company website. This ensures that the **UPS PIco** keeps flexible and always has the latest version of firmware. New versions of the firmware are announced on the www.pimodules.com website and can be downloaded by the user. The **UPS PIco** firmware is smart enough to automatically recognize which hardware model of **UPS PIco** it is running on and adjust the available functionality set to it. The boot loading procedure uses the Raspberry Pi® serial interface, therefore the user needs to take care to keep this inteface free from any other applications during the firmware upload process. A few simple steps are needed to make the **UPS PIco** and Raspberry Pi® cooperative in order to upload the newer firmware. A detailed description how to do this is provided in the next sections.

Setting Up the RaspberryPi® Serial Port for other applications (i.e. Bootloader)

By default Raspberry Pi®'s serial port is configured to be used for console input/output. While this is useful if you want to log in using the serial port, it means that you can't use the Serial Port in your programs. To be able to use the serial port to connect and talk to other devices, the serial port console logins need to be disabled.

Needless to say, if you do this then you need some other way to log in to the Raspberry Pi®; we suggest using an SSH connection over the network.

Disable Serial Port Login

To disable logins on the serial port, there are two files that need to be edited. The first and main one is /etc/inittab. You can edit it by issuing this command[1]:

sudo nano /etc/inittab

This file contains the command that enables the login prompt, that needs to be disabled. Move to the end of the file: you will see a line similar to:

T0:23:respawn:/sbin/getty -L ttyAMA0 115200 vt100

Disable it by adding a # character to the beginning, as shown here below, then save the file.

#T0:23:respawn:/sbin/getty -L ttyAMA0 115200 vt100

[1] throughout this manual we will assume that text files are edited with nano and that the user knows how to save the file, after editing. However, instead of nano the user is free to use any other text editor that he or she feels comfortable with.

Disable Boot-up Info

When the Raspberry Pi® boots up, all the boot log information is sent to the serial port. Disabling this boot log information is optional and you may want to leave this enabled as it is sometimes useful to see what happens at boot and if you have a device connected (i.e. Arduino) at boot, you might want it to receive this information over the serial port, so it is up to you to decide whether to keep this boot logging enabled or disable it.

If you decide to disable it, you can do it by editing the file /boot/cmdline.txt:

sudo nano /boot/cmdline.txt

The content of the file looks like this

dwc_otg.lpm_enable=0 console=ttyAMA0,115200 kgdboc=ttyAMA0,115200 console=tty1 root=/dev/mmcblk0p2 rootfstype=ext4 elevator=deadline rootwait

Remove all references to ttyAMA0 (which is the name of the serial port), then save the file and close it. The file will now look like this:

dwc_otg.lpm_enable=0 console=tty1 root=/dev/mmcblk0p2 rootfstype=ext4 elevator=deadline rootwait

Reboot

In order to enable the changes you have made, you will need to reboot the Raspberry Pi:

sudo shutdown -r now

Test the Serial Port

A great way to test out the serial port is to use the ***minicom*** program. If you don't have this one installed and you are connected to Internet, then you can install it by running

sudo apt-get install minicom

Run up ***minicom*** on the Raspberry Pi® using

minicom -b 38400 -o -D /dev/ttyAMA0

Make sure that the jumpers required for serial connection (**RXD0** and **TXD0**) are installed and that no other boards using the serial port are placed on the top of the **UPS PIco**.

Figure 1 UPS PIco Jumpers

By pressing the **UPSR** (the UPS Reset Button) you should see on the ***minicom*** screen the **UPS PIco** welcome message after reset. This will ensure you that the **UPS PIco** is cooperating properly with your Raspberry Pi ®.

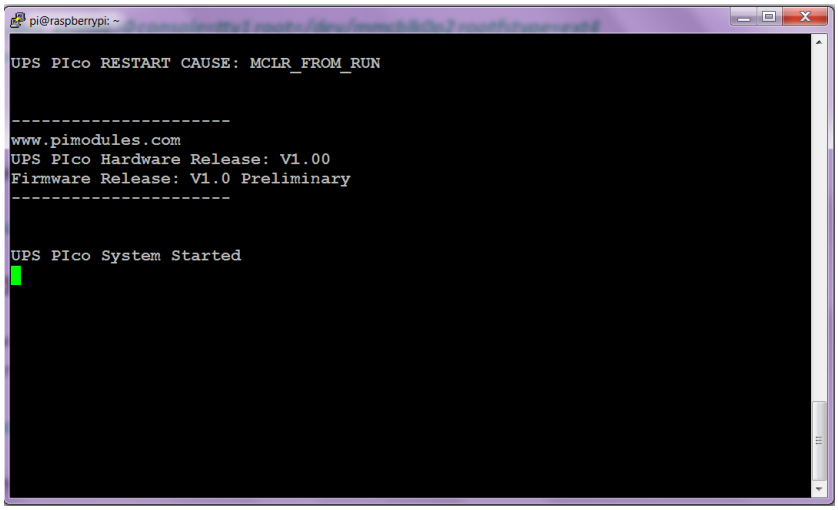

Figure 2 Minicom screenshot while the UPS PIco restarts

Be careful when pressing the **UPSR** (the UPS Reset Button) to avoid pressing also the **RPIR** (the Raspberry Pi® Reset Button), because that other button would force a reset of the Raspberry Pi® and cause the immediate cutting of communication between the **UPS PIco** and the Raspberry Pi®.

NOTE1: Resetting of the **UPS PIco** does not reset the Raspberry Pi®.

NOTE2: Resetting of the **UPS PIco** does reset the simulated RTC to default values.

NOTE3: Resetting of the Raspberry Pi® does not reset the **UPS PIco**, therefore the RTC keeps working and the time information is not lost.

NOTE4: Resetting of the Raspberry Pi® is possible only if the **Reset Gold Plated Pin** is installed (soldered).

Setting-up the I2C interface and RTC

The **I²C** Ports on the Raspberry Pi® are not enabled by default. Follow these steps to enable the **I²C** ports and the **RTC** communicate with RaspberryPi® trough **I²C**.

First of all, the config file must be edited that by default disables the **I²C** port. This setting is stored in **/etc/modprobe.d/raspi-blacklist.conf**.

sudo nano /etc/modprobe.d/raspi-blacklist.conf

Once this file is open, find the line **blacklist i2c-bcm2708** and comment it out by adding a hash character (**#**) in front of it as shown here below, then save and close the file.

#blacklist i2c-bcm2708

Now edit /etc/modules:

sudo nano /etc/modules

and add the following lines, then save and close the file.

i2c-bcm2708
i2c-dev
rtc-ds1307

Reboot the system:

sudo reboot

Install **I²C** tools by running the following command (assuming that you're connected to Internet)

sudo apt-get install i2c-tools

Now look for ID #68 with i2cdetect. Depending on the model of your Raspberry Pi, this must be done in two different ways:

- On a 256MB Raspberry Pi Model A+:

  sudo i2cdetect –y 0

- On a 512MB Raspberry Pi Model B+:

  sudo i2cdetect –y 1

The result should look like the following:

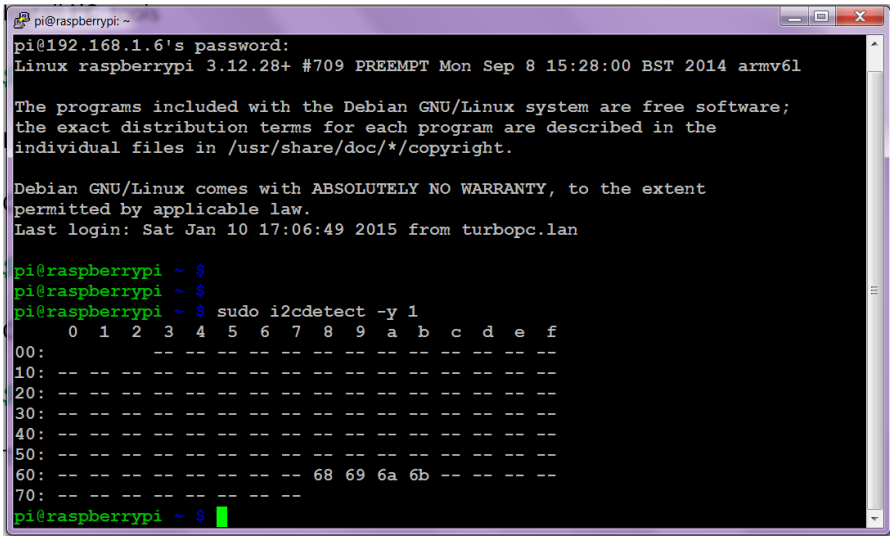

Figure 3 I2C UPS PIco Interface and Simulated DS1307 Clock detection

Then, running as root, do the following (also depending on the model)

- On a 256MB Raspberry Pi Model A+:

  sudo bash
  echo ds1307 0x68 > /sys/class/i2c-adapter/i2c-0/new_device
  exit

- On a 512MB Raspberry Pi Model B+:

  sudo bash
  echo ds1307 0x68 > /sys/class/i2c-adapter/i2c-1/new_device
  exit

The result should look like:

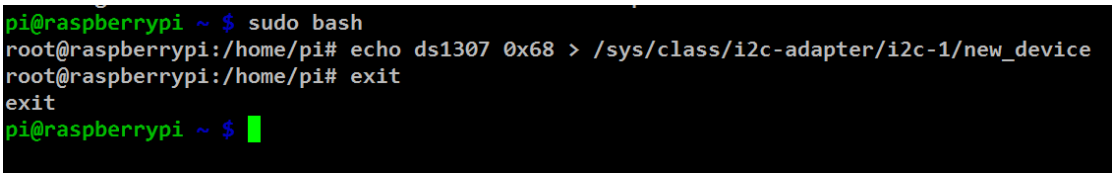

Figure 4 UPS PIco Simulated DS1307 Clock sudo bash commands execution

Then check for time from the clock (which will show Sat 01 Jan 2000 if it is the first time that it is used):

sudo hwclock -r

Then write the current system time to the clock:

sudo hwclock -w

Finally edit the /etc/rc.local file:

sudo nano /etc/rc.local

and just before the line that reads ***exit 0***, add the following two lines, then save and close the file:

- On a 256MB Raspberry Pi Model A+:

  echo ds1307 0x68 > /sys/class/i2c-adapter/i2c-0/new_device
  hwclock -s

- On a 512MB Raspberry Pi Model B+:

  echo ds1307 0x68 > /sys/class/i2c-adapter/i2c-1/new_device
  hwclock -s

Running the UPS PIco Bootloader

In order to keep **UPS PIco** module firmware up-to-date, an embedded serial bootloader has been implemented. In order to upload the new firmware to the **UPS PIco**, a dedicated bootloader ***python*** program needs to be run on the Raspberry Pi®. It is mandatory to have previously installed the ***python*** and ***I2Ctools***. The activation of **RTC** is not mandatory for the new firmware uploading.

There are two ways to invoke the bootloader mode and to upload the new firmware:

1. The manually initiated one:

   The bootloader is invoked when the **UPS PIco** module starts from **UPS PIco** RESET **UPSR** key and the **KEYA** button is pressed during startup. In practice, the user must press and hold the **UPSR** button, then press the **KEYA** button while the **UPSR** button is still pressed, then relase the **KEYA** button and finally release the **UPSR** button.

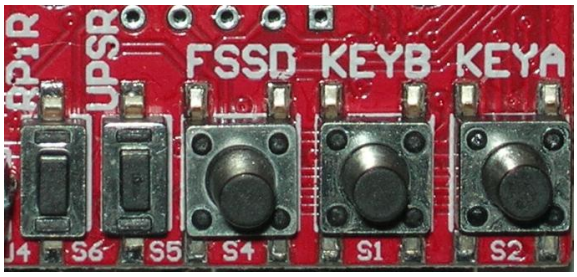

Figure 5 UPS PIco Keys

As a result, the **UPS PIco** module enters the bootloader mode, and informs you about this by lighting the red LED. It will keep waiting for the start of the new firmware uploading as long as needed. The following command needs to be executed in order to start the new firmware upload procedure (please make sure that the new firmware has been already downloaded and stored onto the Raspberry Pi® mass storage):

sudo python picofu.py -f UPS_PIco.hex

Just after the new firmware starts to upload, the red LED lights off and the blue LED starts flashing, and keeps flashing until the firmware is completly uploaded. The following screen will be visible.

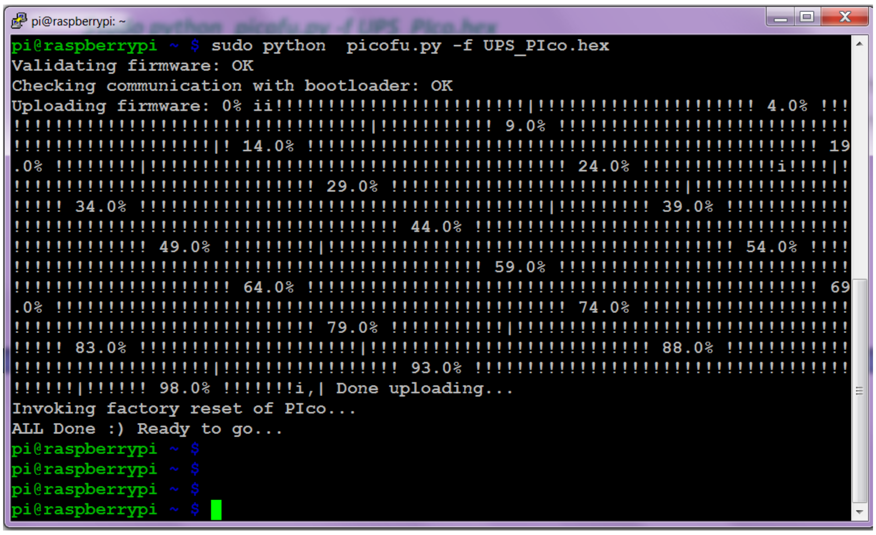

Figure 6 Screenshot of the UPS PIco uploading new firmware

2. The automatically initiated one:

   The bootloader is invoked by running the following command line

   sudo i2cset -y 1 0x6b 0x00 0xff && python picofu.py -f UPS_PIco.hex

   Execution of this command will make the red LED light for a short time, then the blue LED starts flashing and the new firmware is uploaded. This automatic firmware upload can be used when the Raspberry Pi® is placed in a remote place and the **UPS PiCO** firmware needs to be updated remotely. This automatic firmware uploading uses the **PICo** interface (**P**eripherals **I**2C **Co**ntrol – PICo – Interface) which is described in another document.

RaspberryPi® File Safe Shutdown Procedure and RaspberryPi® RUN

The **File Safe Shutdown** feature saves files from corruption by executing a proper shutdown of the OS on the RaspberryPi® before that it's powered off. The **FSSD** (**F**iles **S**afe **S**hut **D**own) can be executed automatically when some events happen, or on user request by pressing the **FSSD** Button. The usage of the **FSSD** needs a Python script running on the RaspberryPi®. This FSSD script covers also one additional functionality (the RaspberryPi® RUN) that informs the **UPS PIco** if the RaspberryPi® is running.

In any case the user must bear in mind some of the basics of the implemented circuit on the **UPS PIco** board:

- There are no Pull-Up resistors on the **UPS PIco** board therefore the user needs to setup the RaspberryPi® resistors.
- The Pin which has been dedicated for the **FSSD** is the pin **GPIO.27** and the Pin which has been dedicated for the **RUN** is the pin **GPIO.22**. Before this functionality can be used, the user needs to make sure that the two jumpers **FSSDR** and **FSSDU** are installed on the **UPS PIco** Board, otherwise it will not work.
- If the user does not need this functionality (but, on the contrary, **we highly recommend to use it**), or needs to use these pins for other applications, then the **GPIO.27** pin and **GPIO.22** pin could be used for other applications provided that the associated jumpers are open (removed). Note that in this way other important functionalities will become unavailable too, as the **UPS PIco** interacts with RaspberryPi® just via these pins.

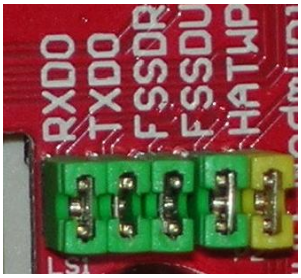

Figure 7 UPS PIco Jumpers

In order to support the **File Safe Shutdown** procedure, a simple Python script must be downloaded from the website www.pimodules.com and must be stored on the RaspberryPi® with this full file name:

/home/pi/picofssd.py

Then you have to add some code to enable the Python script created to run when the RaspberryPi® boots up. Type in:

sudo nano /etc/rc.local

locate the line that says

exit 0

and then add this line of code just before that line:

sudo python /home/pi/picofssd.py

then save and exit.

You can easily test the installation by writing on the command line

sudo python /home/pi/picofssd.py

and then pressing the **FSSD button** for longer than 2 seconds. If you have properly performed the above tasks, the computer should print on the screen the following message and then shutdown.

The system is going down for system halt NOW!

If, at the same time, a minicom session is active on the RaspberryPi® to monitor the messages from the UPS PIco, then the following message will also appear on that session:

UPS PIco System Started File Safe Shutdown Procedure

After the **File Safe Shutdown** procedure has completed and the RaspberryPi® is halted, you can restart your RaspberryPi® using the **Reset Functionality** (using the **RPiR** button) or disconnect and then reconnect the power supply. If the system is running from battery power back-up, then it goes automatically to Low Power Mode.