UPS PIco HV3.0 HAT

Versions Stack/TopEnd/Plus/PPoE

Uninterruptible Power Supply with Peripherals and I²C control Interface

User Guide

Designed for the Raspberry Pi® 3

Compatible with

Raspberry Pi® 2, Pi Zero, A+, B+,

HAT Compliant

Document Revisions

Version	Date	Modified Sections	Comments
na	06/11/2016	na	First Preliminary Public Document Release
1.0	07/06/2017	all	Public Document Release

Table 1 Document Revisions

Table of Contents

Unlocked Firmware Features

Version	Date	Active Features
Initial	Initial	Interrupts driven interaction with Raspberry Pi® based on Daemons
Initial	Initial	Simple status email broadcasting system based on Daemons
Initial	Initial	Intelligent Uninterruptible Power Supply (UPS)
Initial	Initial	3 User defined keys handler
Initial	Initial	3 User defined LEDs handler
Initial	Initial	LiPO and LiFePO4 chemistry battery support
Initial	Initial	Automatic Battery Charger for LiPO and LiFePO4 batteries
Initial	Initial	Battery Charger Power Tracking (Only Version Plus on External Powering Input)
Initial	Initial	Integrated Hardware RTC with Battery Back-up
Initial	Initial	Automatic Files Safe Shutdown and Wake-up (when Cable Power is back)
Initial	Initial	Single button System Shutdown/Startup and ON/OFF for Battery and Cable (Only Version Plus) Powered Applications
Initial - 0x30	Initial/15.03.2017	PWM FAN Control with automatic ON/OFF (added on 15.03.2017)
Initial	Initial	Zero Power Bi Stable Relay Control
Initial	Initial	Programmable Integrated Sounder
Initial	Initial	System Monitoring: Temperatures, Voltages
Initial	Initial	Programmers I²C PICo Interface
Initial	Initial	Programmers RS232 Interface (Basic Version)
Initial	Initial	Boot loader for onsite firmware update
Initial	Initial	3 x A/D converters (Basic Version, without high voltage interface)
0x30	15.03.2017	3 x A/D converters Raw Data (without conversion to Voltages)
0x30	15.04.2017	Programmable Auxiliary Battery Backed up 5V@750mA and 3.3V@150mA supply
0x34	15.04.2017	User Selectable PIco HV3.0 I²C addresses (NORMAL, NO_RTC, ALTERNATE)
0x35	20.05.2017	Activated Still Active Timer (watch-dog for the Raspberry Pi)
0x39	15.07.2017	Activated Events Triggered RTC Based System Actions Scheduler

Table 2 Unlocked Firmware features

Firmware and Manual Fixes/Add on

Version	Code	Date	Firmware and Manual Fixes and Add-ons
0x24	24.001	15.01.2017	Enable/Disable and set data rate of the PIco RS232 is now working. Fixed default to disabled RS232. Fixed data rate programmable by user written to PIco EEPROM. Usage is described in the manual in a proper section.
0x24	24.002	15.01.2017	Activated Register **charger** at **0x69** and address **0x20** informing user if battery charger is ON or OFF. Usage is described in the manual in a proper section.
0x24	24.003	15.01.2017	Corrected bug with low battery threshold shutdown for **LiPO** and **LiFePO4** batteries, to 2.95V and 3.5 V
0x24	24.004	15.01.2017	Added full **LiFePO4** battery charger cutoff @3.75V
0x24	24.005	15.01.2017	Added for **LiPO** and **LiFePO4** battery charger trickle charging starts up threshold to 4.1V and 3.6V respectively. This threshold is in additional controlled by the charger IC itself.
0x24	24.006	15.01.2017	User Manual re-structure
0x24	24.007	15.01.2017	Activated Register **key** at **0x69** and address **0x1A** informing user about the pressed **User Key (A, B or C)**. Usage is described in the manual in a proper section.
0x24	24.008	15.01.2017	Changed Battery Powering Backup activation threshold from **4.75V** on 5V GPIOs to **4.65V** **Remark:** Now the UPS PIco HV3.0 is checking the following conditions for Battery Power Backup activation on the following conditions: 1. Continuously Fast Falling Powering Edge Monitoring (proprietary algorithm) 2. GPIO 5V powering is unconditionally lower than 4.65V This will help when used lower quality PSUs that are giving higher voltage drop than should be when system is loaded. In any case we **strongly recommend** using PSU with micro USB cable on the same body with the PSU, and minimum, recommend **3A.**
0x24	24.009	15.01.2017	Corrected (and activated) option with Battery Voltage measure **batlevel** at **0x69** and address **0x08** informing user about It. This option was temporary (in former version of firmware - 0x18) disabled to rewrite firmware part procedures from floating point arithmetic to fixed one, in order to decrease memory footprint and system speed-up. Usage is described in the manual in a proper section.
0x24	24.010	15.01.2017	Corrected (and activated) option with Raspberry Pi Voltage measure **rpilevel** at **0x69** and address **0x0a** informing user about It. This option was temporary disabled to change firmware from floating point arithmetic to fixed one, in order to decrease memory footprint and system speed-up. Usage is described in the manual in a proper section.
0x24	24.011	15.01.2017	Corrected (and activated) option with Raspberry Pi Voltage measure **eprlevel** at **0x69** and address **0x0c** informing user about It. This option was temporary disabled in order to change firmware from floating point arithmetic to fixed one, in order to decrease memory footprint and system speed-up. Usage is described in the manual in a proper section.
0x24	24.012	15.01.2017	Corrected (and activated) option for the first A/D converter pre-scaled to 5.2V at **0x69** and address **0x14**. This option was temporary disabled to change firmware from

			floating point arithmetic to fixed one, to decrease memory footprint and system speed up. Higher Voltage **could not be** supplied to this A/D converter. Readings are in 10th of mV in BCD format. Usage is described in the manual in a proper section.
0x24	24.013	15.01.2017	Corrected (and activated) option for the first A/D converter pre-scaled to 5.2V at **0x69** and address **0x16**. This option was temporary disabled to change firmware from floating point arithmetic to fixed one, to decrease memory footprint and system speed up. Higher Voltage **could be** supplied to this A/D converter when added an extra resistor and set a proper variable in the PICo interface. Readings are in 10th of mV in BCD format. Usage is described in the manual in a proper section. **The High Voltage Conversion interface is not activated yet.**
0x24	24.014	15.01.2017	Corrected (but not activated) option for the first A/D converter pre scaled to 5.2V at **0x69** and address **0x18**. This option was temporary disabled to change firmware from floating point arithmetic to fixed one, to decrease memory footprint and system speed up. Higher Voltage **could be** supplied to this A/D converter when added an extra resistor and set a proper variable in the PICo interface. Readings are in 10th of mV in BCD format. Usage is described in the manual in a proper section. **The High Voltage Conversion interface is not activated yet.**
0x24	24.015	15.01.2017	Corrected the option with PIco Serial Port Data Rate selection and activation/deactivation (RS232) **rs232_rate** at **0x6B** and address **0x02.** Default option is PIco RS232 is disabling (available for user applications). Usage is described in the manual in a proper section.
0x24	24.016	15.01.2017	Corrected (activated) Battery Selection independent of the boot loader pre-settings.
0x24	24.017	15.01.2017	Improved the cable reentry recognition time, checking is every 5 seconds
0x30	30.018	24.01.2017	Changed low battery thresholds shutdown for **LiFePO4** batteries from to 2.95V to 2.9V. Now for battery LiFePO4 **BAT LED** is now lighting at 2.95 V, and FSSD is at 2.9V. For battery LiPO **BAT LED** is now lighting at 3.6 V, and FSSD is at 3.4V.
0x30	30.019	24.01.2017	**PIco HV3.0 Plus**: Corrected bug when executed command in Raspberry Pi “sudo halt” system not goes to the Low Powering Mode when powered from External Powering Input. Now System is going to Low Powering Mode, and cut the cable power when “sudo halt” is executed. If “sudo reboot” is executed system restarts the Raspberry Pi. When system is in Low Powering Mode, can be wake up if: - any cable power applied or change their conditions (EXT, micro USB or GPIO 5V) - **F** button pressed
0x30	30.020	24.01.2017	Changed waiting time for reboot or shutdown, if console command has been executed “sudo halt” or “sudo reboot” from 300 secs (as it was) to 90 sec now.
0x30	30.021	28.01.2017	Improved the Powering Falling Edge Recognition algorithm
0x30	30.022	28.01.2017	Improved the A/D converter filtering software by using (adding) the “Olympic Scoring” implementation on each A/D sampling interrupt instead of the former used “windowed mean value” method
0x30	30.023	10.02.2017	Added software low pass filter to each of the PIco HV3.0 A/D converters (users and system)
			Added decimal rounding on second position after comma to each A/D Voltage Translator readings (0x69 Registers Set). Each A/D reading converted to voltage/temperature/current are valid on the first position after comma. Therefore the 4.16V is shown as 4.20V, 4.12V is shown as 4.10V.

0x30	30.024	15.02.2017	Improved Keys recognition routine
0x30	30.025	25.02.2017	Improved the de-bouncing filter on the ISR of the pulse train input recognition
0x30	30.026	28.02.2017.	Improved the TO-92 temperature sensor readings and conversion
0x30	30.027	05.03.2017	Improved the NTC temperature sensor readings and conversion
0x30	30.028	10.03.2017	Corrected (and activated) option for the first A/D converter pre-scaled to 5.2V at **0x69** and address **0x16**. This option was temporary disabled to change firmware from floating point arithmetic to fixed one, to decrease memory footprint and system speed up. Higher Voltage **could be** supplied to this A/D converter when added an extra resistor and set a proper variable in the PICo interface. Readings are in 10th of mV in BCD format. Usage is described in the manual in a proper section. **The High Voltage Conversion interface is not activated yet.**
0x30	30.029	11.03.2017	Improved LF batteries charging algorithm
0x30	30.030	12.03.2017	Improved wake up procedure from sleep mode when Raspberry Pi is starting up
0x30	30.031	12.03.2017	I2C ISR Improved and tested to be workable with new preliminary kernel 4.9.11
0x30	30.032	12.03.2017	Added option for the all 3 A/D converters a Raw Data Readings, with internal Reference to 2.048V (always with Internal Resistors divider presented on a dedicated manual part). Each reading is passed from the “Olympic Score filtering” as also software Low Pass Filter. There are not rounded as also not converted to voltage. Just raw data. In order to ready the user, need to write the **0xFF** to the **setA_D register**.
0x30	30.033	13.03.2017	Improved the Dynamic Power Tracking and separated currents for micro USB and External Powering with different current thresholds. The EPR has higher current 800 mAh
0x30	30.034	14.03.2017	Activated enable **5V.** The usage of it is described in detailed in a proper manual section
0x30	30.035	15.03.2017	Improved storage/recall of system variables in the internal **UPS PIco HV3.0 HAT** EEPROM
0x30	30.036	15.03.2017	Activated automatic FAN controls, set as default option, temperature thresholds are: 35 Celsius for ON and 34 Celsius for OFF (1 Celsius hysteresis). User can change the threshold; however, the hysteresis will be always 1 Celsius. Default the FAN speed is set to 50%, user can change it. FAN is NOT working when system is in Low Powering Mode
0x30	30.037	17.03.2017	Updated the default Start-up/EEPROM Stored Values
0x30	30.038	18.03.2017	Added LED OFF, which switches OFF all software, controlled LEDs. CHG, FAN, EXT cannot be switched off as are connected to the hardware and controlled by it. By writing the 0x00 to LEDOFF disable the LEDs. Default is 0x01 (means LED ON)
0x31	31.039	20.03.2017	Significantly improved the switching ON of the integrated battery charger IC.
0x32	32.040	10.04.2017	Corrected bug (generated in the 0x30) with RS232 deactivation. Now the if the RS232 is deactivated for PIco (and free for Raspberry Pi Applications) the TXD and RXD pins are HiZ and not High Level like before.
0x32	32.041	15.04.2017	Internal Improvements making system more robust and smaller

0x32	32.042	15.04.2017	Corrected bug with remain voltages on auxiliary 5V@750 mA and 3.3V@150 mA. Now when auxiliary voltages are off, are exact 0V, and when battery backed up are respectively 5V and 3.3V
0x35	35.043	01.05.2017	Added Extra Option moving/changing the UPS PIco HV3.0 I^{2}C addresses base to the following: DEFAULT, NO_RTC, and ALTERNATE.
0x35	35.044	01.05.2017	Improved the low pass filter in the EPR measure system to have more stable and accurate reading
0x35	35.045	01.05.2017	Final I^{2}C ISR Improvements and tested to be workable with new kernel 4.9.11 including sometimes I^{2}C handler after Low Powering Mode (sometimes not working properly)
0x35	35.046	20.05.2017	Activated Still Active Timer (watch-dog for the Raspberry Pi)
0x36	36.047	25.05.2017	Improved the Factory Defaults Procedure
0x36	36.048	25.05.2017	Improved de-bouncing procedure for user keys
0x36	36.049	25.05.2017	Improved Interrupts Nesting Handler
0x37	37.050	10.06.2017	Improved Low Powering Mode entering
0x39	**39.051**	**15.07.2017**	**Activated Events Triggered RTC Based System Actions Scheduler**
0x40	40.052	20.07.2017	Activated Disable/Enable of Sounder System Audio information
0x40	40.053	20.07.2017	System Messaging Texts Simplified (shorted)
0x40			**Activated Basic System Scheduler**
			Improved EPR measurements, increased filtering, values are updated every 4 seconds
			Rewritten the I^{2}C interrupts handler

Table 3 Firmware and Manual Fixes/Add on

System Overview

Introduction

The **UPS PIco HV3.0A** is an advanced uninterruptible power supply designed for the for the **Raspberry Pi® 3 (but compatible also with the Raspberry Pi 2, and Raspberry Pi Zero)** that adds a wealth of innovative power back-up functionality and development features to the innovative micro-computer!

Offers now total **3A** current from the External Power Supply or battery backup, **3** User Keys, 3 User LEDs, **3** different types of high capacity batteries, 2 x **3** pins **bi-stable relay** (Zero Power), as also **3 x A/D 12 bit** converters with pre adjustable readings to 5V, 10V, 20V and 30V conversion (when used with **Terminal Blocks PCB** or separate external resistor). Now, with additional **External Supply Powering Input**; that has implemented **Dynamic Power Tracking**; automatically adjust battery charging current according to power availability from 100mA – 1000 mAh, to use all available energy from the Solar Panel in case of use. This feature has been especially designed to support **Solar Panel Powering Raspberry Pi® Systems**, as it is adjusting the charging battery current to available Sunning conditions. The **External Supply Powering Input** is able to accept power from **7 V DC** up to **28 V DC!!** Thus, make it ideal for Cars, Trucks, Buses and any industrial applications where voltage is usually higher than 24V DC. The **External Supply Powering Input** is equipped with Over Current protection, Over Voltage as also **with Zero Voltage Drop Inverse Polarity Protection** protecting Raspberry Pi System form improper usage, but due to zero voltage drop to use all available energy from the Solar Panel in case of use. The New **UPS PIco HV3.0A** is an all-in-one tool that allows implementing easy and fast simple applications as also complicated projects providing a set of pre-installed peripherals.

The **UPS PIco HV3.0A** is standard equipped with a 450 mAh 15C LiPO battery specially designed to enable **safe shutdown** during cabled power cut and **automatic system restart** when cabled power comes back. The included battery provides enough energy to keep running system for 10-15 minutes in case of absence of the cable power. Additionally, this can be easily upgraded to the extended **4000mAh** version, **8000 mAh** as also **12000 mAh** batteries (optional on special request), which enables prolonged use of a Raspberry Pi for **more than 32 hours** without a power supply connected (with biggest battery installed)!

The **UPS PIco HV3.0A** design support now batteries with different chemistry: **LiPO** as also **LiFePO4**. Especially the **LiFePO4** batteries are addressed to applications where temperatures environment is more restricted as can be used for supplying from **-10 degrees up to +60 degrees**. In addition, the **LiFePO4** have a unique extremely long life of charging/discharging that can achieve up to **2000 cycles!!**

The implemented trimmed **Hardware Real Time Clock and Calendar**, guarantees time stamp when system is running without access to the Network. The **Hardware RTCC** is backed up and powered from the integrated system battery.

The integrated Hardware **RTCC** enables a new extremely usefully feature – the **Events Triggered RTCC Based System Actions Scheduler**. The **Events Triggered RTCC Based System Actions Scheduler** allows to timely start up, or shutdown the **Raspberry Pi®** on various internal or external events that include, data available on RS232, IR, A/D, RTCC, and temperature, Opto Coupled Input or just on requested Time Stamp.

Professional developers often need to protect their application. To support them **UPS PIco HV3.0A** offers the **XTEA** dual path encryption (on read and write path) embedded engine that protect the developed software with the secure code**.**

The **UPS PIco HV3.0A 450 mAh Stack Plus** offers **2.6A** battery power backup for the **Raspberry Pi®** via GPIOs as also **3A** extended power supply, but not only. In addition is offered an independent from the **Raspberry Pi®** powering, battery backed output of **5V@750 mA** and **3.3V** available for the user devices connected to the **Raspberry Pi®** that must be running even if the mother **Raspberry Pi®** is shut down and not powered (i.e. USB powered HUBs, WiFi Routers, Motion Detectors, HDDs etc). The total current cannot exceed 3A. The current supply delivered via GPIOs to the **Raspberry Pi®** is **2.6A**

Many applications need to have **secondary RS232** in addition to the primary one offered by the **Raspberry Pi®**. Until today, it has been solved by users with add-on hardware put on the top. Not anymore!! With the **UPS PIco HV3.0A** user have access to integrated secondary serial port 3.3V level but save also to be used with 5V level. This makes the developed application cost effective and more robust

Now with **additional Terminals Blocks** Add-on PCB **UPS PIco HV3.0A** offers a professional I/O connectivity for any industrial application including 12V level converter for both Serial Ports (one of them must be selected).

The **Zero Power Bi Stable Relay** offers two independent sets of terminals, each one offers up to 1A contacts able to switch ON/OFF various peripherals of the developed system. Due to unique design, no power is required when Bi Stable Relay is in Set/Reset state, making it ideal for battery powered applications. Two independents 3 pins sets offered (NC, NO, CO) are switched at the same time and are able to relay 2 independent applications.

Now, the high voltage signal can be monitored safely with the **Opto Coupled interface**, which can be read as digital as also analogue input.

The **IoT** developers will find useful the **3 ESD protected 12 bits buffered A/D converters** as also number of internal sensors and sensor interfaces that can be used for system monitoring such as Battery Voltage, External Powering Voltage, Raspberry Pi Voltage, Current Consumption**,** System Temperature and 1-wire interface.

Especially with the added **Terminals Blocks** Add-on PCB user can preset A/D converters to scaled measure of 5V, 10V, 20V, as also 30 V with a simple jumper selection or external resistor. In addition, the **Terminals Blocks** Add-on PCB offers one A/D converter f**ollowed voltage follower** with input impedance of 1M Ohm, allowing very high impedance sensors connectivity.

The **UPS PIco HV3.0A** 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 HV3.0A** including remotely **ON/OFF.**

The embedded **Electromagnetic Programmable Sounder** can be used as a **simple buzzer** but also as **music player** due to implemented sound generator and dedicated programmer interface.

Finally, the **UPS PIco HV3.0A** 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. The FAN speed can be manually/automatically adjusted according to system temperature conditions linear from 0 % (FAN is OFF) up to 100% by increasing and decreasing rotation speed. Thus, guarantees the possible lowest level of noise and always cool **Raspberry Pi® 3.**

UPS PIco HV3.0 Add-On equipment

The **UPS PIco HV3.0** can be combined with additional already available parts. There are:

1. UPS PIco HV3.0 Fan Kit
2. UPS PIco HV3.0 Relay Kit
3. LiPO Battery 4000 mAh
4. LiPO Battery 8000 mAh
5. LiFePO4 Battery 4000 mAh
6. LiFePO4 Battery 8000 mAh
7. LiFePO4 or LiPO 12000 mAh (only on special order)
8. Terminal Blocks PCB
9. Dedicated **UPS PIco HV3.0** Plexiglas case for battery 4000 mAh LF or LP

UPS PIco HV3.0 Models

The **UPS PIco HV3.0** is available in 5 different models all based on the same PCB:

1. **UPS PIco HV3.0 Stack**
2. **UPS PIco HV3.0 Stack Plus**
3. **UPS PIco HV3.0 Top End**
4. **UPS PIco HV3.0 PPoE (future option – not released yet)**
5. **UPS PIco HV3.0 Top End Plus (future option – not released yet)**

The differences between each model are listed here below in the table with Technical Specifications however the core features for all models are presented here below.

UPS PIco 3.0 HAT Core Features

The list of core features of the **UPS PIco HV3.0** is as follows (for all models):

- Raspberry Pi B+ **HAT Compliant**
- **Plug and Play –** Ultra Simple Semi-**Automatic Installation** via GitHub
- **Interrupts driven interaction with Raspberry Pi® based on Daemons**
- Simple **status email broadcasting system based on Daemons**
- **Intelligent Uninterruptible Power Supply** (UPS)
- **Integrated LiPO Battery** (10-15 Minutes of System Power Back-Up)
- **Intelligent Automatic Charger with Power Tracking** (adjusting the battery charging current according to power availability from 100 mA – 1200 mA) - **implemented only in the UPS PIco HV3.0 Plus and PPoE**
- **No Additional External Power Input Required (if Stack/TopEnd is used)**
- **Optional 4000 or 8000 mAh** Battery for 8 – 16 Hours Run-Time (Not Included)
- **Optional 12000 mAh** Battery for extremely long Run-Time (Not Included – on special request)
- Each High Capacity Battery comes with **dedicated plastic screwed mounting base**
- Support for **LiPO and LiFePO4 batteries** on the same PCB with simple command switching
- **5V 2.6A Power Backup (Short Peak Output 5V 3A)**
- Integrated **Hardware Real Time Clock (RTC)** with Battery Back-Up
- **Automatic File Safe Shutdown** and **Wake-up** Functionality
- **Single button System ON/OFF for battery powered applications**
- **Events Triggered RTC Based System Actions Scheduler (Triggered ON/OFF based on RTC or External Events – voltage, RS232 data, A/D, IR etc)**
- **PWM fan control** (Fan Not Included), FAN PWM interface is integrated on each **PIco HV3.0** PCB
- **3 User Defined LEDs** for their own user application
- **3 User Defined Buttons** for their own user application

- **Separate TH Soldering Pads for each user button and FSSD** for external button connection
- **Bi Stable Relay (Zero Power) with dual separated independent contacts (Standard UPS PIco HV3.0 Plus or PPoE Only, optional for the UPS PIco HV3.0)**
- **Additional 5V (independent from Raspberry Pi® powering) power source with battery backup,** available for user applications also when Raspberry Pi is OFF (5V@750mA) **protected with PPTC FUSE** and **reverse current flow diode**
- **Optical Isolated input (opto coupler) – readable also as A/D values (UPS PIco HV3.0 Plus Only)**
- **Programmable Integrated Sounder** for UPS and User Applications (able to play music)
- **Status Monitoring** - Powering Voltage, UPS Battery Voltage, Current and Temperature
- **I^{2}C PICo Interface** for Control and Monitoring
- **RS232 Raspberry Pi®** Interface for Control and Monitoring
- **Double path XTEA Based Cryptography** for User Software Protection
- 2 Level **Watch-dog Functionality** with **FSSD and unconditional Hardware Reset (if system Hangs-up)**
- **Extended Voltage Input 7-28V DC protected with zero voltage drop inverse polarity protection (UPS PIco HV3.0 Plus Only)**
- **Direct Raspberry Pi® Hardware Reset Button via Spring Test Pin (Pogo pin)**
- **16 pins Stack-able Header** for **PIco** Add-On Boards
- **Boot Loader** for Live Firmware Update
- **Intelligent IR Remote Power ON/OFF** (if **IR** received installed) **(UPS PIco HV3.0 Plus Only, or system shutdown – all models)**
- **Infra-Red Receiver** Sensor Interface (IR Not Included) directly connected to the GPIO18
- Integrated EDS-Protected **3 Channel A/D 12 Bit Converters 0-5.2V** (optional per-scaled to 10V, 20V and 30V via **Terminals Blocks PCB** add-on or external resistor)
- Optional **A/D converter** with **voltage follower** (ideal for **IoT** applications) - via Terminals Blocks PCB add-on boards to 16 pins header

- **Integrated ESD-Protected 1-Wire Interface**
- **Programmable second RS232 interface (5V tolerant)**
- **12V RS232 interface via Terminals Blocks PCB**
- **Labeled J8 Raspberry Pi® GPIO Pins** for Easy Plug & Play of experimental cables
- **Fits inside to the Official Raspberry Pi® Case with closed lid (version Top End)**
- **Fits Inside Most Existing Cases**

UPS PIco 3.0 HAT Technical Specifications

Features	UPS PIco HV3.0 A Models		
	UPS PIco HV3.0 A Stack 450	**UPS PIco HV3.0 A Stack 450 Plus**	**UPS PIco HV3.0 A TopEnd 450**
Raspberry Pi®			
Raspberry Pi® System Compatibility			
Compatible Raspberry Pi Models	Designed for Raspberry Pi® 3 Compatible with Pi2, Pi3, Pi Zero, A+, B+	Designed for Raspberry Pi® 3 Compatible with Pi2, Pi3, Pi Zero, A+, B+	Designed for Raspberry Pi® 3 Compatible with Pi2, Pi3, Pi Zero, A+, B+
Cases Compatibility			
Cases	Most of the cases ModMyPi cases PiModules PIco case	Most of the cases ModMyPi cases PiModules PIco case	Most of the cases **Recommended Raspberry Pi Original Case** adopted to Media Player Applications
Raspberry Pi® GPIO Usage (occupation)			
Permanent use of I²C (User selectable addresses)	GND, 5V, SDA0, SCL0 I²C Addresses 1: **68 69 6a 6b 6c 6d 6e 6f** I²C Addresses 2: **58 59 5a 5b 5c 5d 5e 5f** I²C Addresses 3: **69 6b**	GND, 5V, SDA0, SCL0 I²C Addresses 1: **68 69 6a 6b 6c 6d 6e 6f** I²C Addresses 2: **58 59 5a 5b 5c 5d 5e 5f** I²C Addresses 3: **69 6b**	GND, 5V, SDA0, SCL0 I²C Addresses 1: **68 69 6a 6b 6c 6d 6e 6f** I²C Addresses 2: **58 59 5a 5b 5c 5d 5e 5f** I²C Addresses 3: **69 6b**
Selectable use of Raspberry Pi® RS232	TXD0, RXD0 OFF(HiZ)	TXD0, RXD0 OFF(HiZ)	TXD0, RXD0 OFF (HiZ)
Selectable use of Raspberry Pi® GPIO	GPIO_GEN22 (pulse train generator) GPIO_GEN27 (System Shutdown initiator) GPIO_GEN18 (if IR receiver is used) GPIO_GEN4 (if 1-wire is used)	GPIO_GEN22 (pulse train generator) GPIO_GEN27 (System Shutdown initiator) GPIO_GEN18 (if IR receiver is used) GPIO_GEN4 (if 1-wire is used)	GPIO_GEN22 (pulse train generator) GPIO_GEN27 (System Shutdown initiator) GPIO_GEN18 (if IR receiver is used) GPIO_GEN4 (if 1-wire is used)
Interactions with Raspberry Pi®			
Battery and Charger			
Supported Batteries Types			
LiPO 3.7V with silicone high current cables			
	Standard - LiPO 450 mAh	Standard - LiPO 450 mAh	Standard - LiPO 450 mAh (dedicated to be used with Raspberry Pi Original Case)
	Optional - LiPO 4000 mAh	Optional - LiPO 4000 mAh	
		Optional - LiPO 8000 mAh	
LiFePO4 3.2V with silicone high current cables			
	Optional – LiFePO4 4000	Optional - LiFePO4 4000 mAh	
		Optional - LiFePO4 8000 mAh	
		Optional - LiFePO4 12000 mAh (due to big size of batter only on special order)	
Battery Life Charge/Discharge Cycles			
LiPO	450 cycles	450 cycles	450 cycles
LiFePO4	2000 cycles	2000 cycles	2000 cycles
Battery Charger			
	Standard - Continues fixed current 303 mAh	Automatic Dynamic Power Tracing Charger with charging	Standard - Continues fixed current 303 mAh

		current 100 mA – 1000 mA, triggered by voltage changes on the 5V GPIO or External Power Source	
Charging Modes			
LiPO	Automatic Selected : Full Charging Cycle Trickle Charging	Automatic Selected : Full Charging Cycle Trickle Charging	Automatic Selected : Full Charging Cycle Trickle Charging
LiFePO4	Automatic Selected : Full Charging Cycle Trickle Charging	Automatic Selected : Full Charging Cycle Trickle Charging	Automatic Selected : Full Charging Cycle Trickle Charging
Battery Protection			
450 mAh	On board cut-off protection system when thermal, overcharge or over discharge	On board cut-off protection system when thermal, overcharge or over discharge	On board cut-off protection system when thermal, overcharge or over discharge
High Capacity LiPO and LiFePO4	On board cut-off protection system when thermal, overcharge or over discharge On battery, additional PCM protection	On board cut-off protection system when thermal, overcharge or over discharge On battery PCM additional protection	On board cut-off protection system when thermal, overcharge or over discharge On battery PCM additional protection
Battery Electrical Isolation System	Battery is Electrically Isolated (however cable connected) until system start up for the first time and receive 5V from GPIO	Battery is Electrically Isolated (however cable connected) until system start up for the first time and receive 5V from GPIO or 7-28V from EXT	Battery is Electrically Isolated (however cable connected) until system start up for the first time and receive 5V from GPIO
Battery Back-Up			
System Battery Backup	Standard – 5V 2.6A current continuous supply to Raspberry Pi via GPIO Pins	Standard – 5V 2.6A current continuous supply to Raspberry Pi via GPIO Pins	Standard – 5V 2.6A current continuous supply to Raspberry Pi via GPIO Pins
Auxiliary 5V and 3V3 Battery Backed Supply on PIco I/O Pins	Standard – 5V 750 mA current and 3V3 continuous supplies on PIco I/O Pin battery backed, with possibility to continuous supply auxiliary devices with Raspberry Pi disconnected. Total system current should not exceed 3A.	Standard – 5V 750 mA current and 3V3 continuous supplies on PIco I/O Pin battery backed, with possibility to continuous supply auxiliary devices with Raspberry Pi disconnected. Total system current should not exceed 3A.	Standard – 5V 750 mA current and 3V3 continuous supplies on PIco I/O Pin battery backed, with possibility to continuous supply auxiliary devices with Raspberry Pi disconnected. Total system current should not exceed 3A.
Battery Back-up Type			
UPS	UPS Standby Type, with switch over time of 250 uS, during switching time the protected system (Raspberry Pi® with added hardware) is powered by auxiliary online power source for maximum 10mS, therefore no power gap on GPIO during switching time	UPS Standby Type, with switch over time of 250 uS, during switching time the protected system (Raspberry Pi® with added hardware) is powered by auxiliary online power source for maximum 10mS, therefore no power gap on GPIO during switching time	UPS Standby Type, with switch over time of 250 uS, during switching time the protected system (Raspberry Pi® with added hardware) is powered by auxiliary online power source for maximum 10mS, therefore no power gap on GPIO during switching time
Powering Monitoring Point	Raspberry Pi® GPIO 5V	Raspberry Pi® GPIO 5V	Raspberry Pi® GPIO 5V
UPS Activation Powering Triggers	GPIO 5V pins <=4.65V Proprietary Algorithm of Falling Power Peak Analysis	GPIO 5V pins <=4.65V Proprietary Algorithm of Falling Power Peak Analysis	GPIO 5V pins <=4.65V Proprietary Algorithm of Falling Power Peak Analysis
Cable Powering Reactivation	After 3s of continuously cable powering (without spikes)	After 3s of continuously cable powering (without spikes) on any cable power source (GPIO or External)	After 3s of continuously cable powering (without spikes)
Cable Powering Sources			
Cable Powering Sources			
Raspberry Pi ® GPIO 5V Pins	2.6 A	2.6 A	2.6 A

External Power Source 7 - 28 VDC		3A max (adjusted according dynamic power tracking)	
Additional Features - Peripherals			
HAT Compliant			
HAT EEPROM	Exists	Exists	Exists
HAT Dimensions	Compliant	Compliant	Compliant
PIco I/O Interface			
Independent from Raspberry Pi ® 3.3 V supply @200 mA With battery Back-up (Raspberry Pi ® can be OFF when this power Auxiliary 3.3 V source is available)	Yes	Yes	Yes
ESD Protected 1-wire interface	Yes	Yes	Yes
Independent from Raspberry Pi ® 5.0 V supply @750 mA With battery Back-up (Raspberry Pi ® can be OFF when this power Auxiliary 5 V source is available)	Yes	Yes	Yes
12 Bit A/D converters ESD protected, pre-scaled to 5V, 10V and 20V (on TB PCB) with Sampling rate 100K SPS, buffered	Yes	Yes	Yes
3V3/5V0 RS232 Port that can be programmed as: primary Raspberry Pi® Port Secondary (independent from the existing on Raspberry Pi®)	Yes	Yes	Yes
Optical Isolated Interface (readable as digital or analog)	none	Yes	none
Primary 3 Pin Bi-stable (Zero Power) Relay Interface Rating (resistive) Maximum Switching Current/Voltage on Terminal Block Current/Voltage on 16 Pin Header	Yes (Optional) 1A 32 VDC	Yes 1A 32 VDC	Yes (Optional) 1A 32 VDC
PIco Terminals Block Extension PCB (Supplied separately)			
12 V RS232 converter attached to primary or secondary Serial Port	Yes (Optional with TB PCB)	Yes (Optional with TB PCB)	Yes (Optional with TB PCB)
Terminal Block on Each PIco I/O Interface listed above	Valid only for existing Interfaces	Valid only for existing Interfaces	Valid only for existing Interfaces
PIco Plus Terminal Block Standard Interface			
DC in 7 – 28 V with Power Tracking	none	Yes	none
Secondary 3 Pin Bi-stable (Zero Power) Relay Interface	Optional if Relay Installed	Yes	Optional if Relay Installed
Hardware User Interface			
System LEDs Indicators	UPS, BAT, CHG, HOT, FAN	UPS, BAT, CHG, HOT, FAN, EXT	UPS, BAT, CHG, HOT, FAN
User LEDs Indicators	Blue, Green, Red	Blue, Green, Red	Blue, Green, Red
System Keys	RPiR, UPSR, FSSD	RPiR, UPSR, FSSD	RPiR, UPSR, FSSD
User programmable Keys	AKEY, BKEY, CKEY	AKEY, BKEY, CKEY	AKEY, BKEY, CKEY
External Connectivity to PIco Keys	FSSD, AKEY, BKEY, CKEY (soldering TH pads for cables)	FSSD, AKEY, BKEY, CKEY (soldering TH pads for cables)	FSSD, AKEY, BKEY, CKEY (soldering TH pads for cables)
Audio Interface	Electromagnetic Transducer, with programmable sound duration and frequency, able to play music	Electromagnetic Transducer, with programmable sound duration and frequency, able to play music	Electromagnetic Transducer, with programmable sound duration and frequency, able to play music
Other Features			
Battery Backed Hardware Real Time Clock and Calendar	Yes	Yes	Yes
Bi-Stable (Zero Power) Relay	Yes (optional)	Yes	Yes (optional)

Passive Cooling System	Based on multiple copper layers thermal pipes for heating dissipation	Based on multiple copper layers thermal pipes for heating dissipation	Based on multiple copper layers thermal pipes for heating dissipation
Automatic Active Cooling System (FAN)	Yes (optional if FAN installed) based on temperature of the Raspberry Pi® PCB read by separate external Sensor	Yes (optional if FAN installed) based on temperature of the Raspberry Pi® PCB read by separate external Sensor	Yes (optional if FAN installed) based on temperature of the Raspberry Pi® PCB read by separate external Sensor
Automatic File Safe Shutdown Functionality	Yes	Yes	Yes
Raspberry Pi® Reset via POGO Pin	Yes	Yes	Yes
Automatic Restart on Power Return	Yes	Yes	Yes
Events Triggered RTCC Based System Actions Scheduler	Yes Basic	Yes Extended on more Events	Yes Basic
Real Time Raspberry Pi® current measure	Yes (both ways) Incoming to UPS PIco Outgoing from UPS PIco	Yes (both ways) Incoming to UPS PIco Outgoing from UPS PIco Incoming from Extended Voltage Input	Yes (both ways) Incoming to UPS PIco Outgoing from UPS PIco
Real Time Battery Capacity Measure	Yes (based on System current consumption)	Yes (based on System current consumption)	Yes (based on System current consumption)
Secondary Serial Port (based on software driver)	Yes (future firmware option)	Yes (future firmware option)	Yes (future firmware option)
IR interface	Yes	Yes	Yes
Optimized design for a very low noise A/D operation	Yes Split grounds, extended Improved filtering on PSU High Speed Separate Tracing	Yes Split grounds, extended Improved filtering on PSU High Speed Separate Tracing	Yes Split grounds, extended Improved filtering on PSU High Speed Separate Tracing
Optimized Ultra Low Power design for a long time Battery System Operation	Yes	Yes	Yes
XTEA Encryption	Yes	Yes	Yes
Extended Raspberry Pi® Watch-Dog (Still Alive)	Yes	Yes	Yes
System Monitoring	Battery Voltage, Raspberry Pi® Voltage, Current Consumption by Raspberry Pi® and PIco, Temperature	Battery Voltage, Raspberry Pi® Voltage, External Voltage, Current Consumption by Raspberry Pi®, Temperature	Battery Voltage, Raspberry Pi® Voltage, Current Consumption by Raspberry Pi® and PIco, Temperature
I2C PIco Programmer Interface	Yes	Yes	Yes
RS232 @command Interface on Primary and Secondary Serial Port	Yes	Yes	Yes
Bootloader for Live Firmware Update	Yes	Yes	Yes
PCB Construction			
PCB Manufacturing	4 Layers, 2 OZ Copper, 8mils/8mils Immersion Gold Plated PB Free alloy assembly	4 Layers, 2 OZ Copper, 8mils/8mils Immersion Gold Plated PB Free alloy assembly	4 Layers, 2 OZ Copper, 8mils/8mils Immersion Gold Plated PB Free alloy assembly

Table 4 UPS PIco 3.0 HAT Technical Specifications

Setting up Procedure

What is in the BOX?

This package comes with everything you need to start using the **UPS PIco HV3.0 HAT** right out of the box. It is assembled, tested and contains all required accessories. A little work is necessary to setup the complete Raspberry® and **UPS PIco HV3.0 HAT** in a single full operating system, and this is instructed below.

Each Box contains the following parts:

- 1 x The **UPS PIco HV3.0 HAT** module
- 1 x 40 THT Header (Stack or Top End)
- 1 x Dual layer wide temperature adhesive tape (used for battery mounting) stuck on the bottom side of **UPS PIco HV3.0** battery, or left free in the box
- 1 x Set of spacers (plastic spacers, rubber stick, or screws and plastic spacer tubes, depending of production lot)
- 1 x Separate packed ultra-high current LiPO battery 450 mAh, 6A current
- 1 x Gold Reset Pin (POGO pin)
- 1 x Electromagnetic Sounder
- 2 x 8 pins Headers Strips

Please kindly notice that, due to shipping regulations, LiPO batteries are packed in the same box but are physically or electrically separated and not connected to the **UPS PIco HV3.0** module. It must be connected by the user, and it is a part of the installation procedure.

Hardware Setup for the UPS PIco HV3.0 HAT Stack/TopEnd/Plus

All **UPS PIco HV3.0** modules are based on the same PCB and differ only on assembly options. Therefore, users should know that on each board some components are missing or replaced by another one. The differences between Version TopEnd and Stack are in two points:

- the THT connector does not contain Up Standing Pins on the version TopEnd
- and the Buzzer is ultra-low profile to be able to fit-in to the Official Raspberry Pi case

On each of **UPS PIco HV3.0** are plenty of I/Os other User Interfaces (Keys, Sounder, etc). The below pictures show each version I/Os.

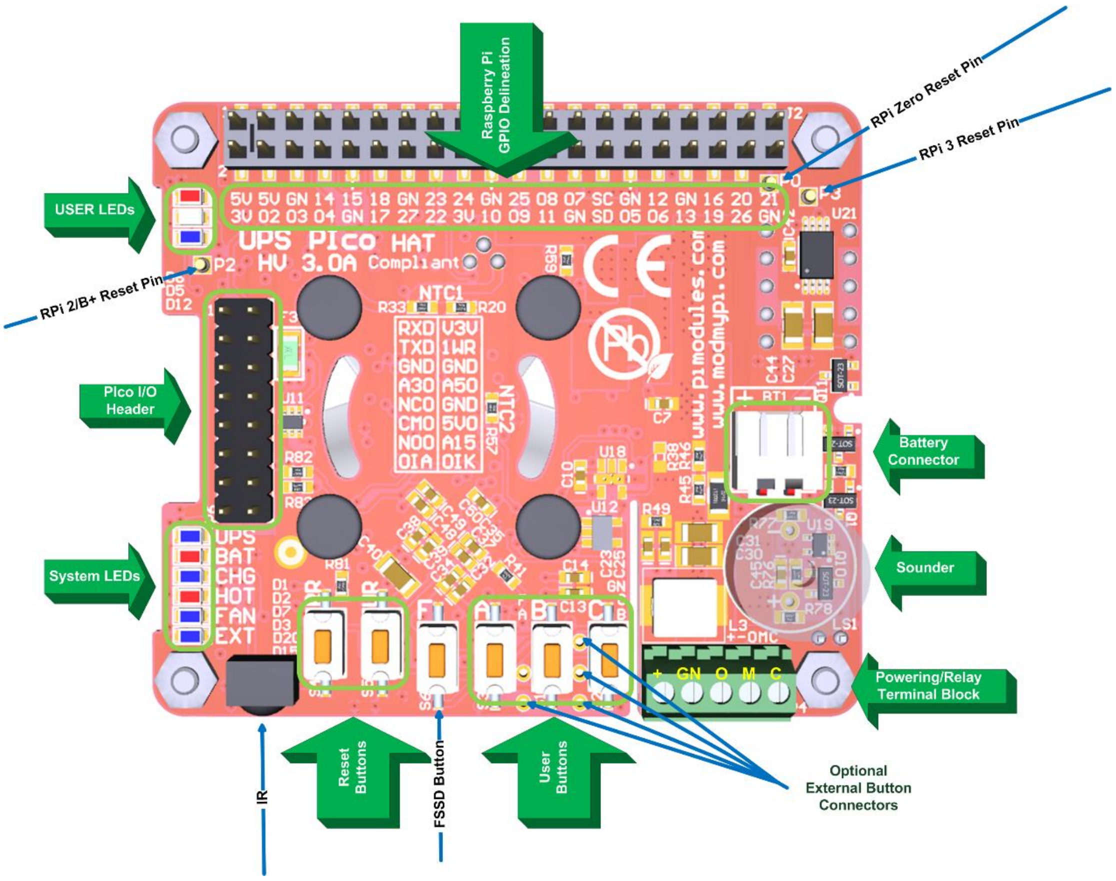

Raspberry Pi GPIO Delineation
RPi Zero Reset Pin
RPi 3 Reset Pin
USER LEDs
RPi 2/B+ Reset Pin
PIco I/O Header
System LEDs
Battery Connector
Sounder
Powering/Relay Terminal Block
Optional External Button Connectors
Reset Buttons
FSSD Button
User Buttons
IR
UPS PIco HAT HV 3.0A Compliant
5V 5V GN 14 15 18 GN 23 24 GN 25 08 07 SC GN 12 GN 16 20 21
3V 02 03 04 GN 17 27 22 3V 10 09 11 GN SD 05 06 13 19 26 GN
UPS BAT CHG HOT FAN EXT
www.pimodules.com
www.modmypi.com

Figure 1 UPS PIco HV3.0A Stack

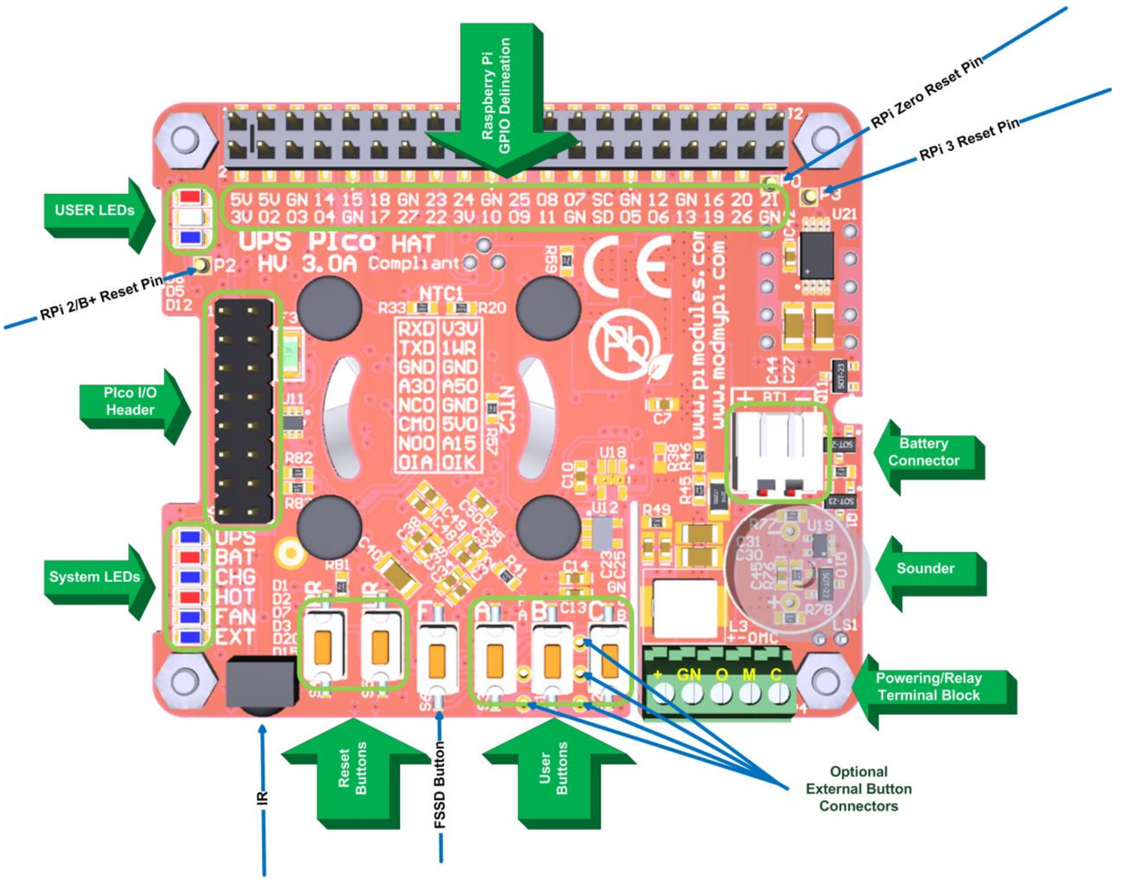


Figure 2 UPS PIco HV3.0A Stack Plus

Interface	Name on PCB	Functionality
40 Pin SMD Connector with delineation	**J2** (Black one placed on the bottom side)	Used for Pass Through the Stack or Top End Connector. Delineation helps users to find a proper GPIO if needed
User LEDs	None - (just 3 LEDs) placed on the left-up corner of PCB	3 color LEDs (Blue, Red, Green) accessed via I2C used for user applications
Gold Pin (POGO pin)	**P0**, **P2**, **P3**	Used for hardware reset of the Raspberry Pi®, each place is specified by the number, therefore: P0 – means Raspberry Pi® ZERO P2 – means Raspberry Pi® 2 P3 – means Raspberry Pi® 3
On Board Temperature Sensor 1	**NTC 1**	Used for PCB temperature measure, as also as an indicator of the environment temperature
On Board Temperature Sensor 2	**NTC 2**	Used by Battery Charger to control the charging process automatically (only in version Plus)
PIco I/O 16 pin (2x8) header	none	Used for various I/O handled by **UPS PIco HV3.0**, detailed described in next chapters
Bi-stable Relay	None - (right up corner – on bottom side)	Bi-stable Relay soldered on bottom, used only for various user applications
Battery Connector	**BAT1**	Battery connector, here should be plug in the battery (any type or size)

System LEDs	**UPS**, **BAT**, **CHG**, **HOT**, **FAN**, **EXT**	System LEDs used by **UPS PIco HV3.0** for messaging to the user on various conditions. Detailed described on next chapters
Sounder	None (inside of circle, just marked **'+'** and **'-'** for soldering)	Used for Sound Generation on various **UPS PIco HV3.0** conditions or user applications
Infra-Red Receiver	**IR** U4	If soldered, then interface the Raspberry Pi® with IR receiver, used for the any IR application
Hardware Reset Buttons	Buttons **RR** and **UR**	Hardware Reset Buttons: **RR** – **R**aspberry Pi® Hardware **R**eset **UR** – **U**PS PIco HV3.0 hardware **R**eset
FSSD Button	Button **F**	**F**ile **S**afe **S**hut **D**own **B**utton – detailed description is in next chapters
User Application Buttons	Buttons **A**, **B**, **C**	Buttons used for User Applications
Cable extensions for the listed Buttons	Holes (THT pads): **F**, **A**, **B**, **C**, **G**	Used for cable extensions of the following buttons if user like to have external buttons i.e. screwed externally on the case: F – FSSD A – Button B – Button C – Button G – GND for buttons
Extended Power Supply (7-28)	**+**, **GND**	Extended Power Supply (7-28) for version UPS PIco HV3.0 Plus
Bi-Stable Relay contacts 1st set	**O**, **M**, **C**	Contacts for the Bi-Stable Relay (1st set) O – Opened when Relay is Reset M – Common C – Closed when Relay is Reset
Connector for the FAN	**LS1**	Used to connect FAN when mounted the FAN kit (placed on bottom)

Table 5 UPS PIco HV3.0A Interfaces

Hardware Interfacing/Interaction with Raspberry Pi®

The **UPS PIco HV3.0A HAT** module is plug on the top of the Raspberry Pi® micro-computer. It is using the GPIOs for interaction with it as also dedicated software installed on the Raspberry Pi® - called Daemons. Only few GPIOs are mandatory to have system cooperative with the Raspberry Pi®, all others are optional and can be used only if needed. Detailed specifications of them are listed below.

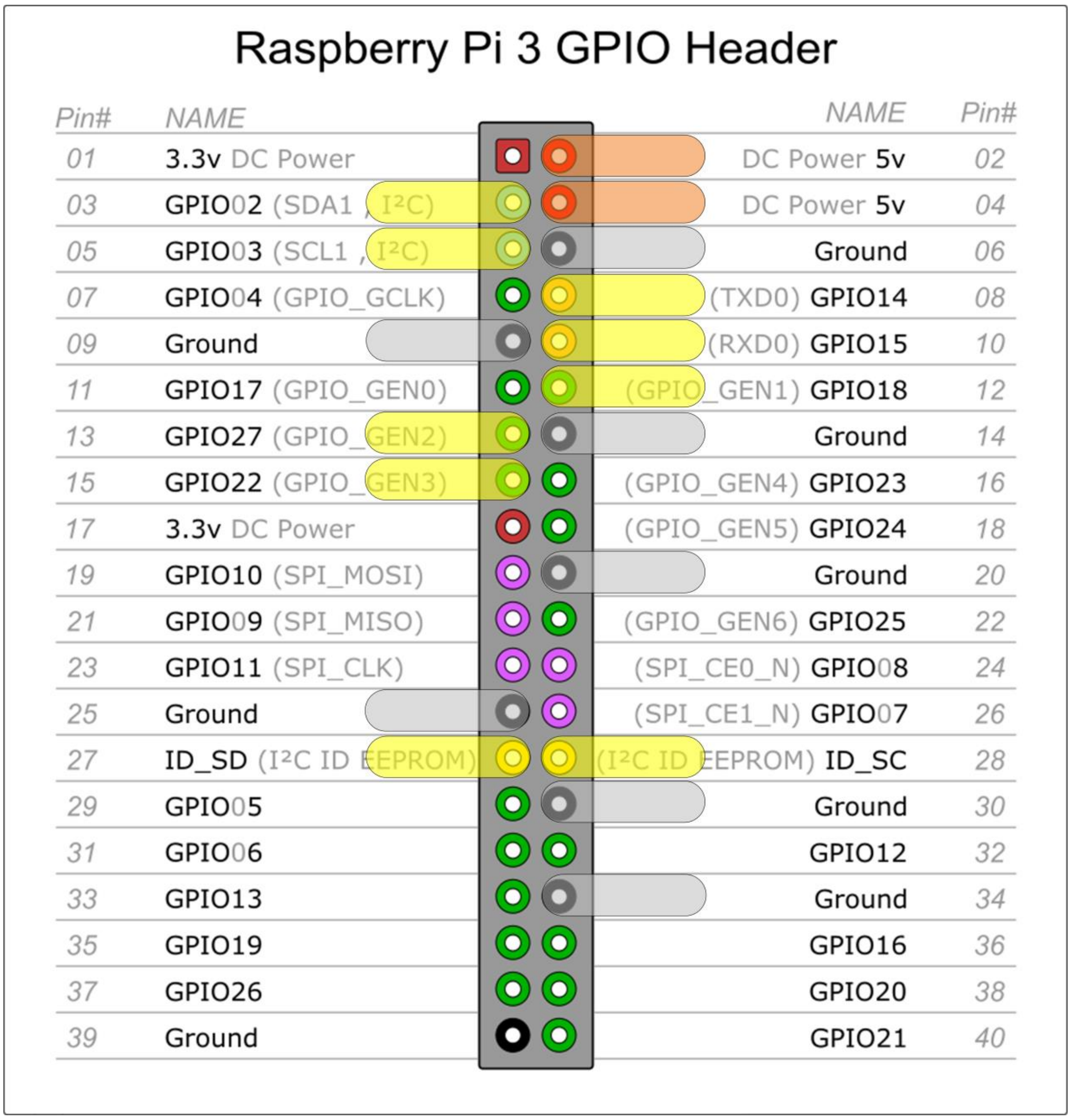

Raspberry Pi 3 GPIO Header
Pin# NAME NAME Pin#
01 3.3v DC Power | DC Power 5v 02
03 GPIO02 (SDA1 , I²C) | DC Power 5v 04
05 GPIO03 (SCL1 , I²C) | Ground 06
07 GPIO04 (GPIO_GCLK) | (TXD0) GPIO14 08
09 Ground | (RXD0) GPIO15 10
11 GPIO17 (GPIO_GEN0) | (GPIO_GEN1) GPIO18 12
13 GPIO27 (GPIO_GEN2) | Ground 14
15 GPIO22 (GPIO_GEN3) | (GPIO_GEN4) GPIO23 16
17 3.3v DC Power | (GPIO_GEN5) GPIO24 18
19 GPIO10 (SPI_MOSI) | Ground 20
21 GPIO09 (SPI_MISO) | (GPIO_GEN6) GPIO25 22
23 GPIO11 (SPI_CLK) | (SPI_CE0_N) GPIO08 24
25 Ground | (SPI_CE1_N) GPIO07 26
27 ID_SD (I²C ID EEPROM) | (I²C ID EEPROM) ID_SC 28
29 GPIO05 | Ground 30
31 GPIO06 | GPIO12 32
33 GPIO13 | Ground 34
35 GPIO19 | GPIO16 36
37 GPIO26 | GPIO20 38
39 Ground | GPIO21 40

Figure 3 UPS PIco HV3.0A GPIO Used Pins

GPIO (Pin #)	**Activity**	**Functionality**
5V – **#02**, **#03** – marked Orange	Powering 5V	Used for monitoring of 5V and when absent the Raspberry Pi® system is powered via it. Protected by ZVD circuit and PPTC fuse of 2.6A
Ground - **#06**, **#14**, **#20**, **#30**, **#34**, **#09**, **#25** - marked Grey	System Ground	System Ground connected to the Raspberry Pi® Ground
TXD0 and RXD0 – GPIO14 and GPIO15 – **#08**, **#10** – marked Yellow	Serial Connection to Raspberry Pi ®	Used for System Monitoring, or firmware uploading – **default is HiZ** (disconnected from the GPIOs), only of user activate them are connected to the GPIOs. During boot loading process are automatically connected, and after that disconnected
IR Input – GPIO18 – **#12** – marked Yellow	Used only if IR soldered on their place on the **UPS PIco HV3.0**	Only if IR is soldered this GPIO18 is valid, all **other cases are HiZ.**
ID_SC – **#28** – marked Yellow	Used for the HAT EEPROM	Used for the HAT EEPROM
I^{2}C – SDA – GPIO02 Used as I2C SDA – **#03** – marked as Yellow	Used as I2C SDA	Used as I2C SDA for communication with Raspberry Pi®
I^{2}C – SCL – GPIO03 Used as I2C SDA – **#05** – marked as Yellow	Used as I2C SCL	Used as I2C SCL for communication with Raspberry Pi®
GPIO27 – **#13** – marked as Yellow	Used as Pulse Train send by **UPS PIco HV3.0** to the Raspberry Pi®	Used as Pulse train to fire Daemons Interrupt in the Raspberry Pi®. This functionality allows PIco to recognize if Raspberry Pi is shutting down, or running properly
GPIO22– **#15** – marked as Yellow	Used as Pulse Train Response from the Raspberry Pi® to the **UPS PIco HV3.0**	Used as Pulse train to fire Interrupts in the UPS **PIco HV3.**0 confirming response of the Raspberry Pi®, as also to shut down the Raspberry Pi®.
ID_SD – **#27** – marked Yellow	Used for the HAT EEPROM	Used for the HAT EEPROM

Table 6 UPS PIco HV3.0A GPIO Usage

Assembly of the THT 40 Pins (2x20) connector

Ensure that you have prepared the Stack or TopEnd THT Connector. To properly pass through the THT connector please follow below instructions:

- Prepare your **UPS PIco HV3.0 HAT,** and make sure that the black SMD 40 pins connector is available

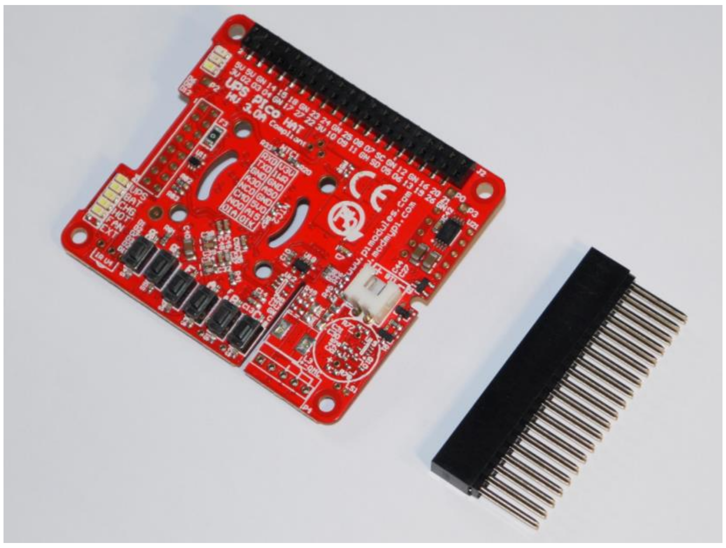


Figure 4 UPS PIco HV3.0 and 40 THT Stack Header

- Put your **UPS PIco HV3.0 HAT** upside down, and make sure that the black SMD 40 pins connector is touching the table

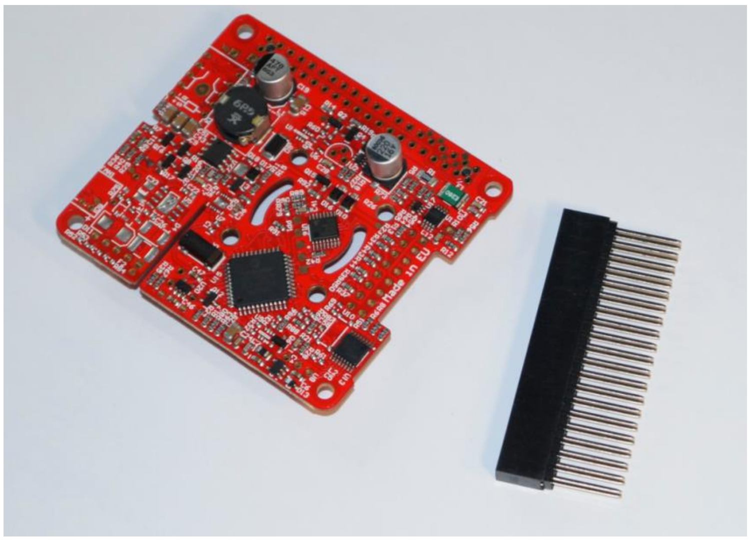


Figure 5 UPS PIco HV3.0 and 40 THT Stack Header bottom side

- Apply the THT 40 Pins connector carefully though the holes on the **UPS PIco HV3.0 HAT SMD**. Apply pressure to the connector making sure you have placed the PCB on something stable, like a table, so the connector can easily fit when it's applied with pressure.

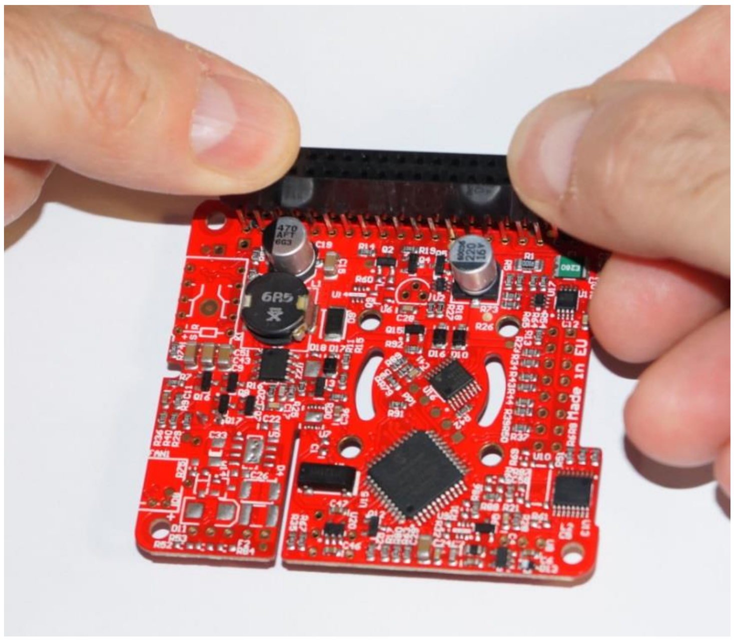


Figure 6 UPS PIco HV3.0 passing the 40 Pins THT connector

- Press the THT 40 Pins connector on the plastic side to complete pass its pins trough, until end of them reaches the bottom of the PCB

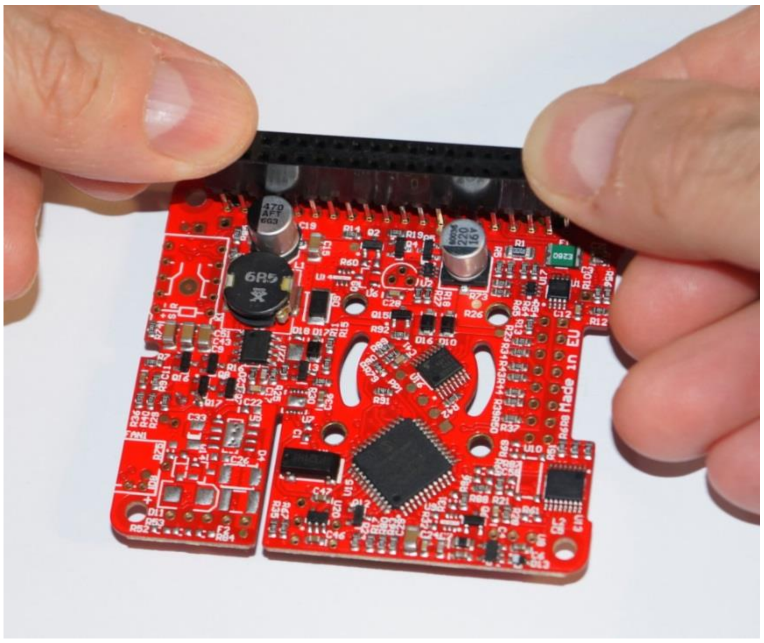


Figure 7 UPS PIco HV3.0 partially passed the 40 Pins THT connector

- Put the PCB and the semi passed connector on the opposite side (this time on the proper one) and then press the PCB on the connector side slowly and carefully until the complete pins pass through, always pressing only the SMD connector and not the PCB itself.

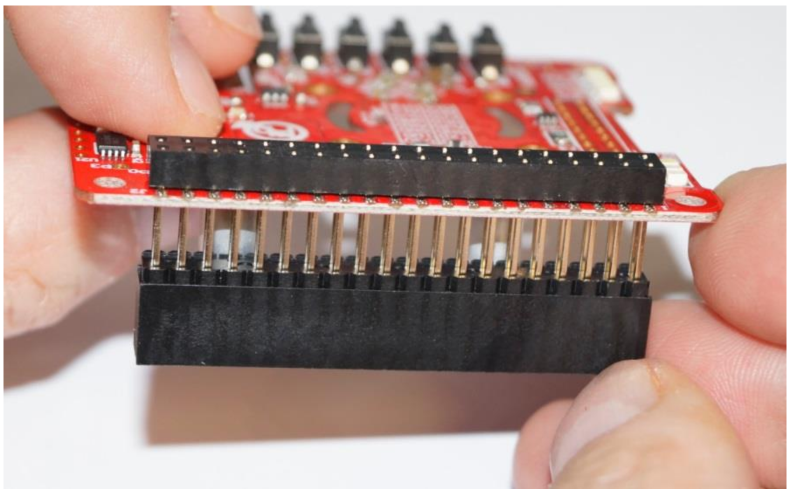


Figure 8 UPS PIco HV3.0 partially passed the 40 Pins THT connector side view

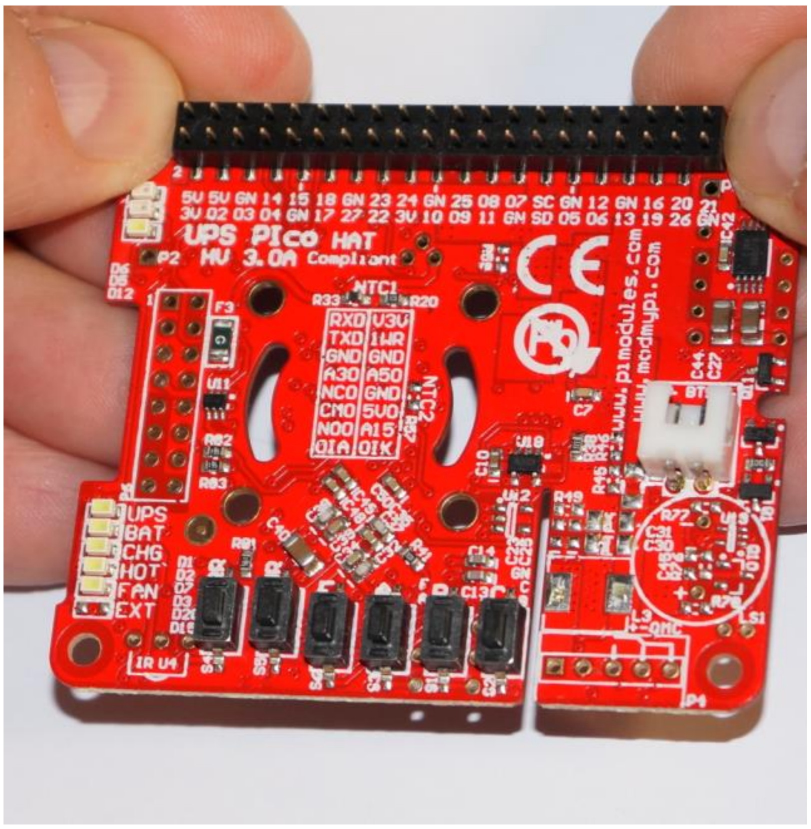


Figure 9 Figure 8 UPS PIco HV3.0 partially passed the 40 Pins THT connector top view

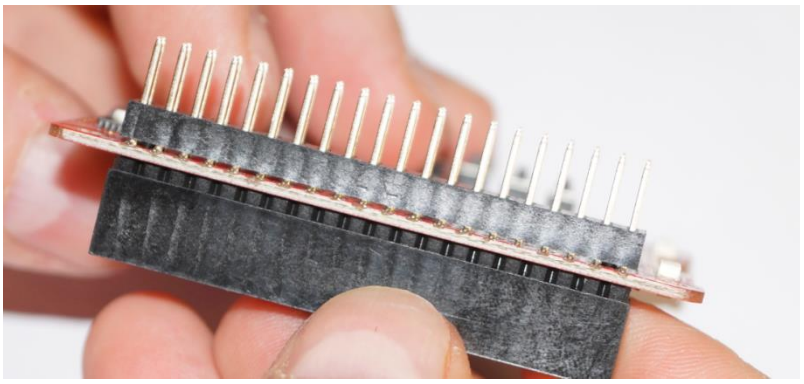


Figure 10 Figure 8 UPS PIco HV3.0 full passed the 40 Pins THT connector side view

Assembling the THT 40 pin Connector for the TopEnd Version is the same, the only difference is that the top pins does not exist.

If you would like to install the **PIco FAN Kit**, please do so now following the instructions below. It is not mandatory to install the fan kit now, but it will enable full function of the **UPS PIco HV3.0 HAT** module.

Assembly of the FAN Kit

One of the add on available for the **UPS PIco HV3.0 HAT** is the FAN Kit. This Kit contains everything what is needed to make it installed on the UPS **PIco HV3.0 HAT** module. There are:

- 1 x Ultra Low Noise DC FAN
- 1 x TO-90 Temperature sensor
- 4 x white 2mm spacers
- 4 x plastic tree clips
- 1 x 2mm connector for the Fan

These instructions will guide you through the installation of the TO92 and FAN.

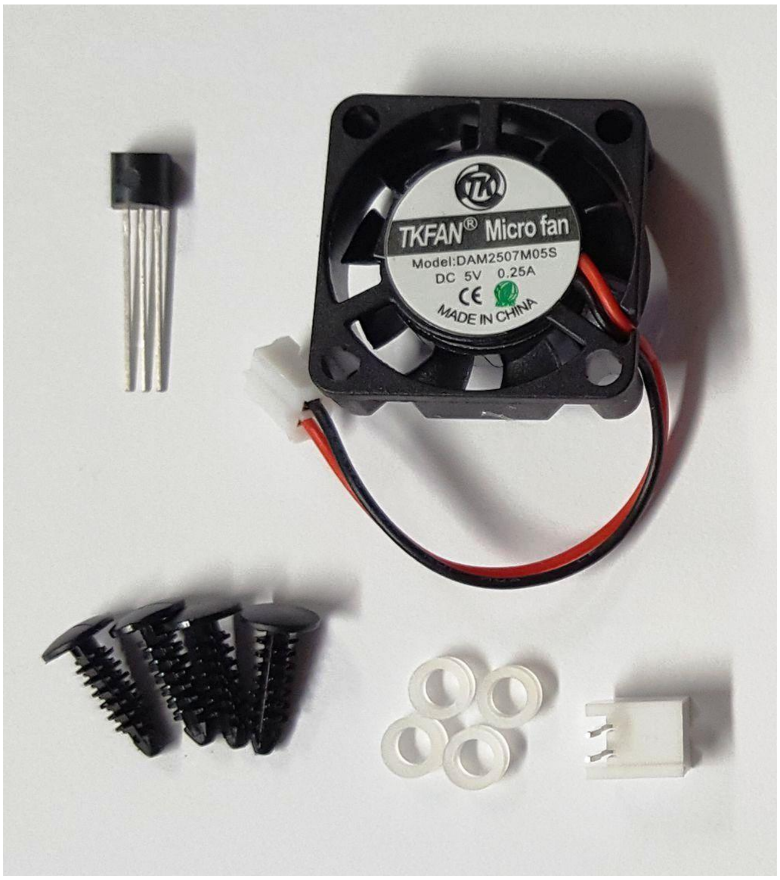


Figure 11 FAN Kit Contents

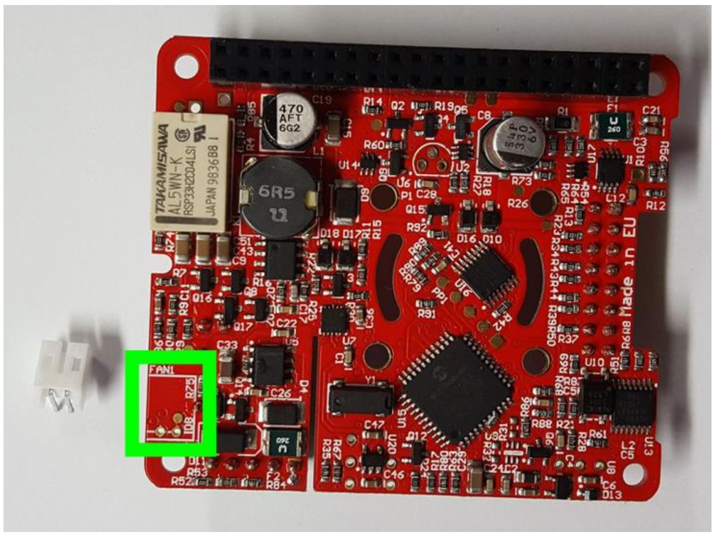


Figure 12 2mm FAN connector placement

Start by soldering the FAN 2mm connector to the **UPS PIco HV3.0 HAT** PCB

Please make sure that before soldering of the 2mm connector, the sounder has been soldered. If not, please solder first the sounder and after that the FAN connector.

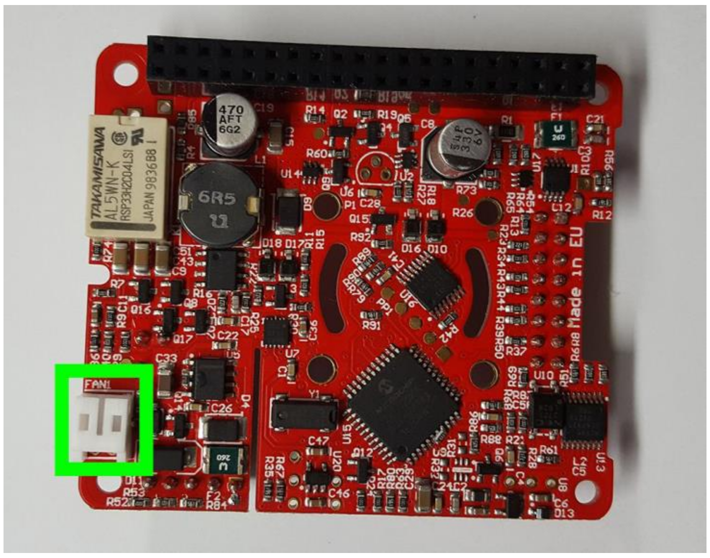


Figure 13 Soldered 2mm FAN connector

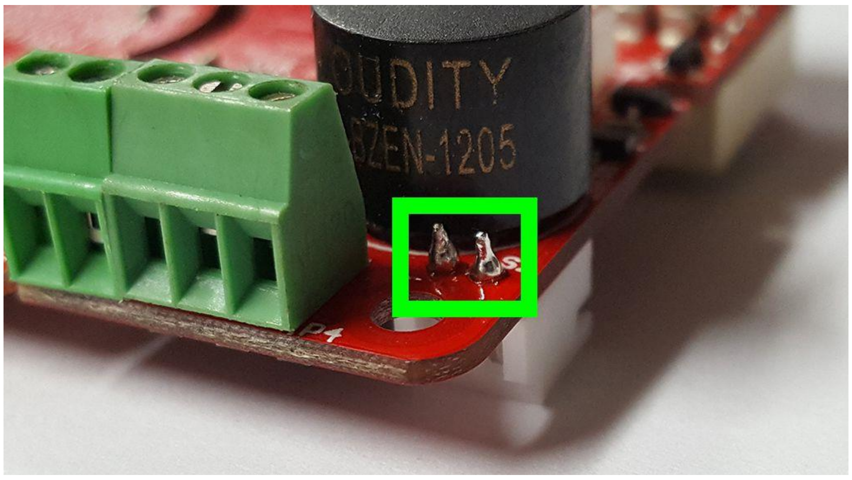


Figure 14 2mm connector on the top side of PCB after soldering

After soldering of the 2mm connector, please cut the outstanding legs.

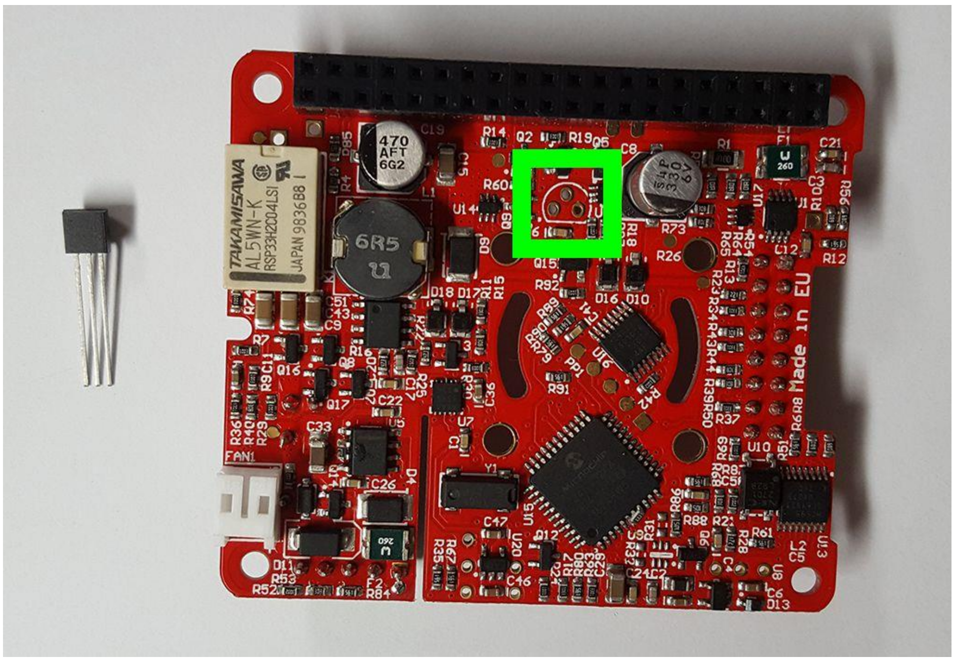


Figure 15 Temperature Sensor fitment place

Next, we'll solder on the TO92 Temperature Sensor. Start by inserting the TO92 into the 3 through holes on the PCB.

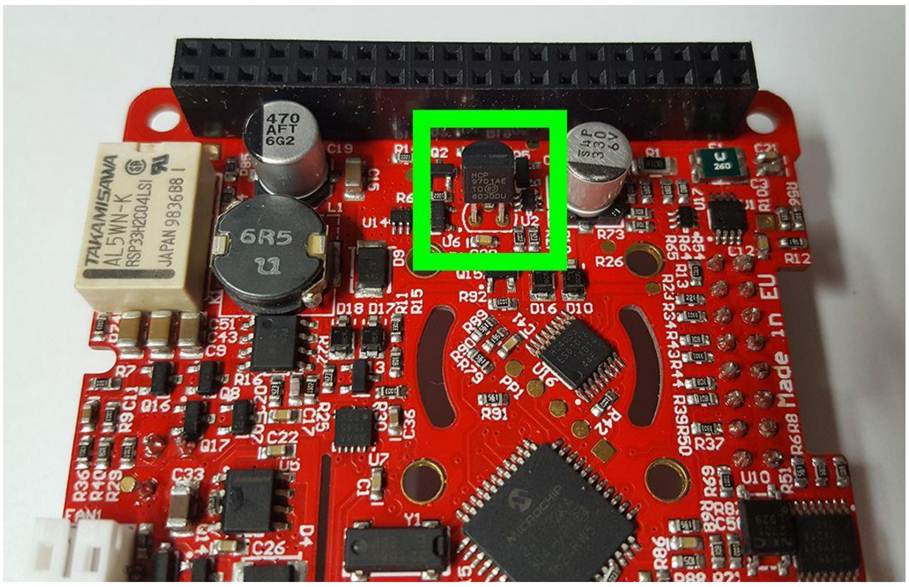


Figure 16 Temperature Sensor passed on the PCB

Flip the **UPS PIco HV3.0 HAT** PCB over, Put the PCB on the Raspberry Pi. Make sure that the spacers have been screwed on the Raspberry Pi and keep the right distance between **UPS PIco HV3.0 HAT** PCB and Raspberry Pi PCB. Press little bit the sensor legs down, to touch the Raspberry Pi PCB and bend the legs out slightly to hold the TO92 in place. It is important to have physical contact of the sensor with Raspberry Pi PCB or to be very close to it (0.5mm – 1mm), to have a proper measure of temperature.

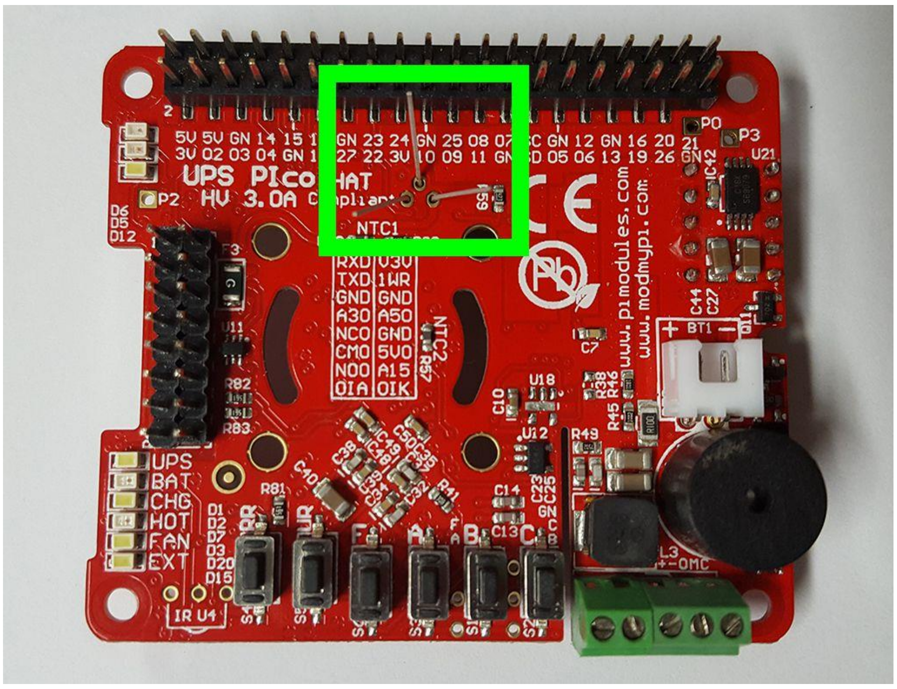


Figure 17 Temperature Sensor legs before soldering

Solder and trim the legs, and cut the remain parts.

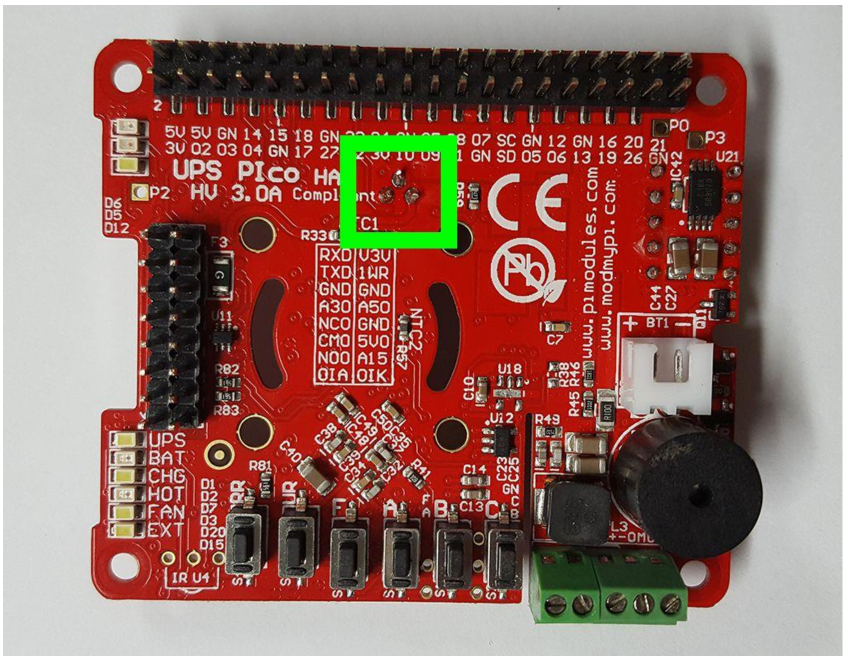


Figure 18 Soldered Temperature Sensor

Now it's time to add the fan. Start by pressing the four studs through the fan mounting holes, from the top of the **UPS PIco HV3.0 HAT**. Do it very carefully, and preferred before installed the Gold-Plated Reset Pin (as when it is installed, it is easy to break it, when pressing them)

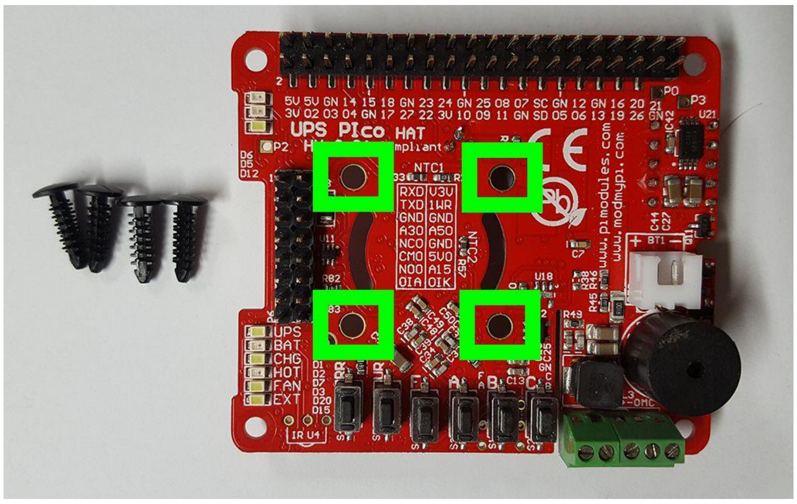


Figure 19 Preparation of the Plastic Tree Clips for FAN

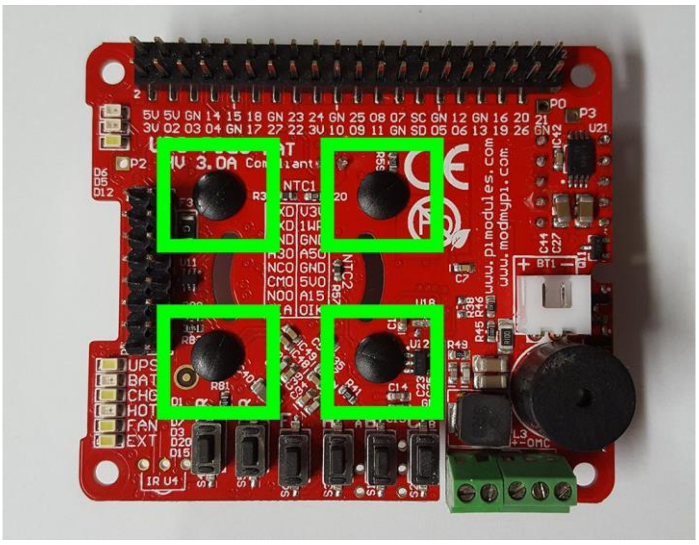


Figure 20 Plastic Tree Clips mounted on the PCB ready for FAN assembly

Flip the **UPS PIco HV3.0 HAT** PCB over.

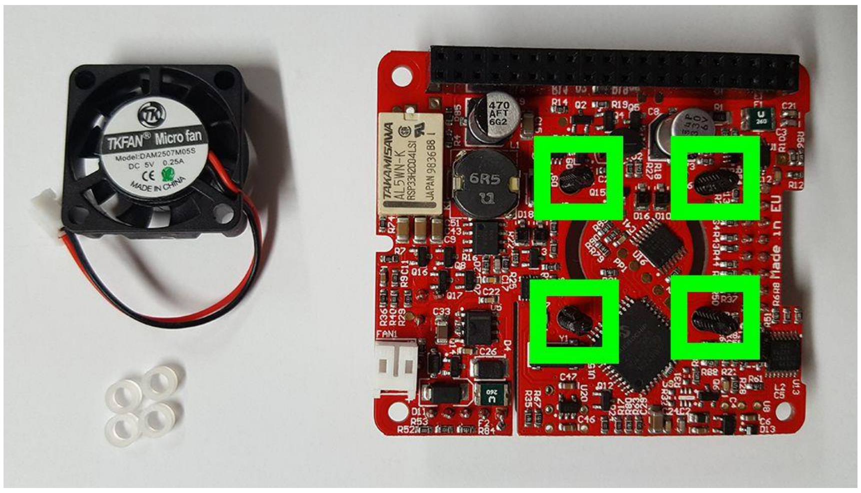


Figure 21 Plastic Tree Clips on the PCB Bottom side

Add a spacer to each of the studs. Finally, add the fan and connect the FAN wire up. The fan blows air towards the label on the FAN. There are 2 ways to mount the FAN. If decided to have this facing down the blow cold air directly onto the SoC of the Pi. It cools better the SoC however collect more dust from outside. If you put on the opposite way (the label on the side of the PCB) then it cools the whole PCB, and collect less dust.

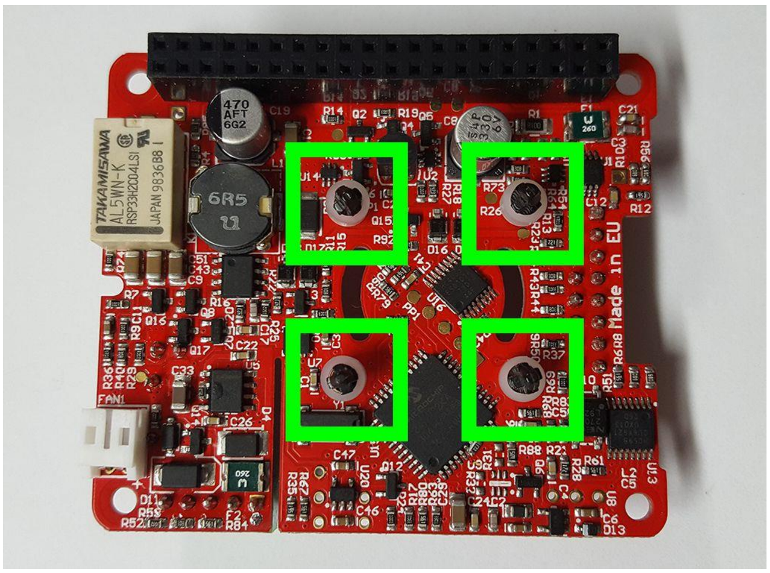


Figure 22 Plastic Tree Clips on the PCB Bottom side with 2mm spacers passed

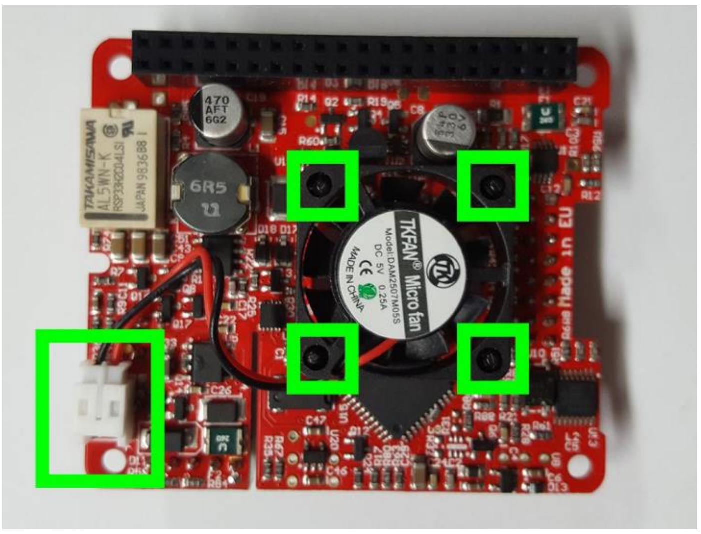


Figure 23 FAN placed on the UPS PIco HV3.0 PCB

When placing the FAN on the Plastic tree clips be very carefully to avoid damaging the FAN propel when pressing it.

Assembly of the Buzzer (Sounder)

If you would like to use the buzzer, you can solder it on now. Ensure that this is done with the correct polarity. Positive “**+**” on the board should match the positive “**+**” on the buzzer. The soldering procedure is same for the High and Low (used in TopEnd Version) profile buzzer.

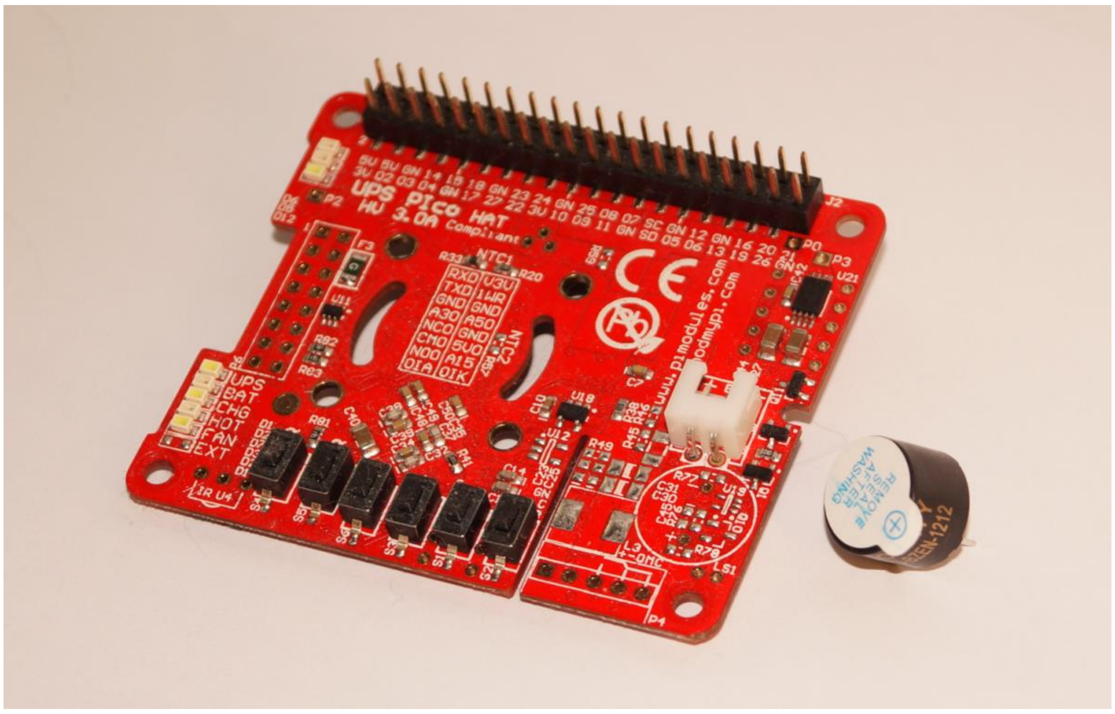


Figure 24 Prepare the UPS PIco HV3.0 HAT and buzzer

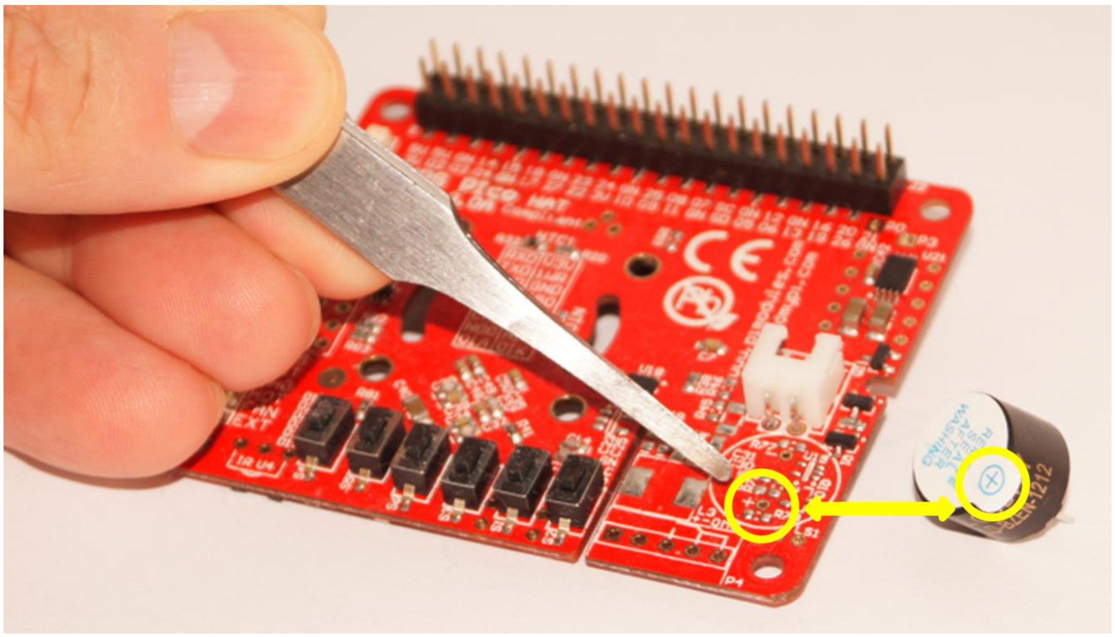


Figure 25 Make sure to solder "+" of the buzzer to the proper place

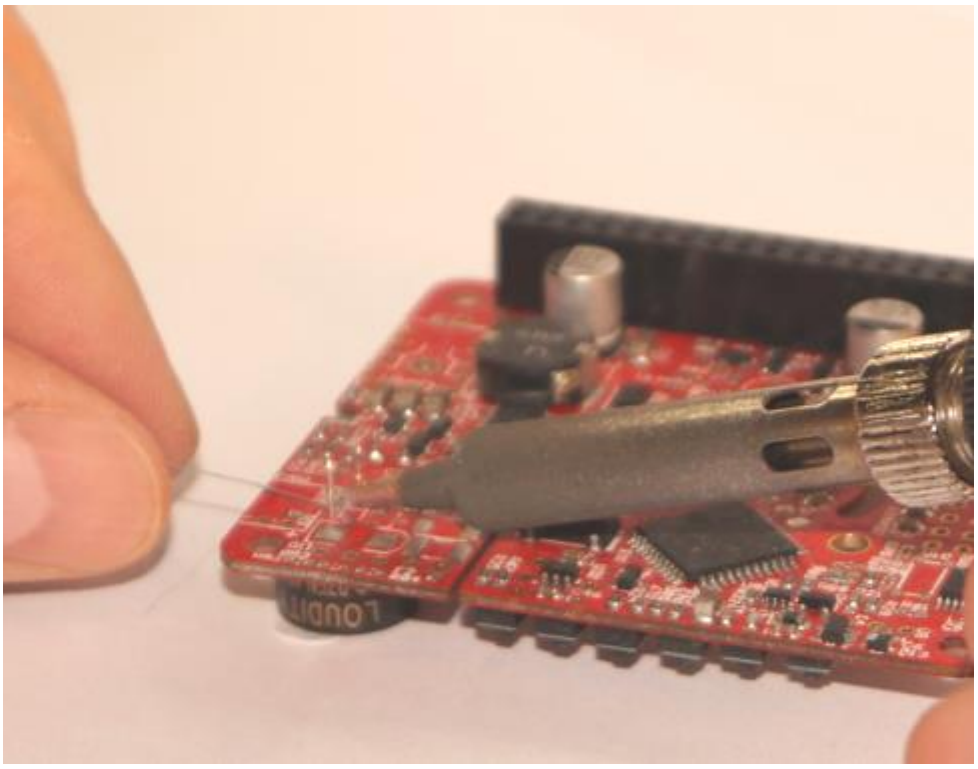


Figure 26 Flip upside down the PCB and colder the pins, then cut the outstanding legs

If you would like to install the Gold-Plated Reset Pin, please do so now following the instructions below. It is not mandatory to install the pin now, but it will enable full function of the **UPS PIco HV3.0 HAT** module. However, it can be installed in next stages.

Assembly of the Gold-Plated Hardware Reset Pin (POGO Pin)

The **Gold Plated Hardware Reset Pin (POGO Pin)** is used to provide various additional functionalities to the **UPS PIco HV3.0 HAT**. It is not necessary, however strongly recomened as additional functionalities covered by it make the **UPS PIco HV3.0 HAT** system more co-operative. It is used with the following functionalities already implemented in the **UPS PIco HV3.0 HAT**, they are:

- Button for Hardware Reset of Raspberry Pi®
- Watch Dog ("Still Alive?") functionality - Automatically Resetting (Restarting) of the Raspberry Pi® when hung-up
- Resetting (Restarting) of the Raspberry Pi® when cable power returns during shutting down process.

There is a very simple hand work needed to solder this pin to the Raspberry Pi®

Place on your desk the **Raspberry Pi®** the **UPS PIco HV3.0 HAT** and the **Gold-Plated Reset Pin**.

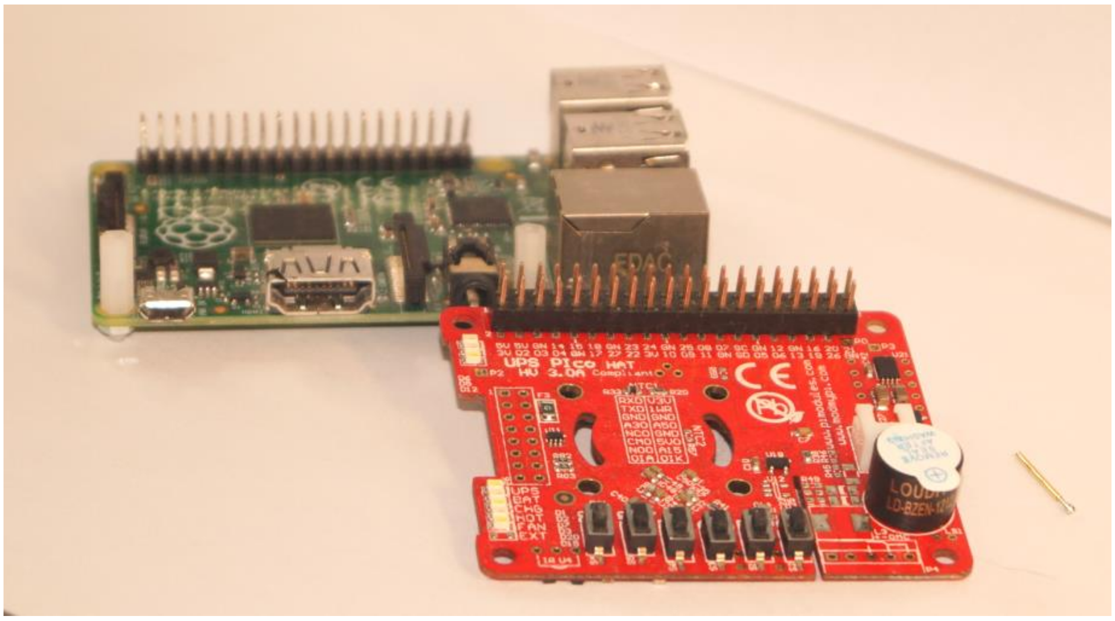


Figure 27 Raspberry Pi, UPS PIco HV3.0 HAT, and Gold-Plated Reset Pin

Drag on the **Gold Plated Reset Pin** through the hole on the **UPS PIco HV3.0 HAT** as shown in the pictures below. Take care to drag on the right direction. Select the proper hole for your Raspberry Pi ® model (P0, P2, P3) marked on the **UPS PIco HV3.0 HAT PCB** (Related to Raspberry Pi® models Zero, 2 and 3)

Drag on the **Gold Plated Reset Pin** on the direction as shown on the below picture.

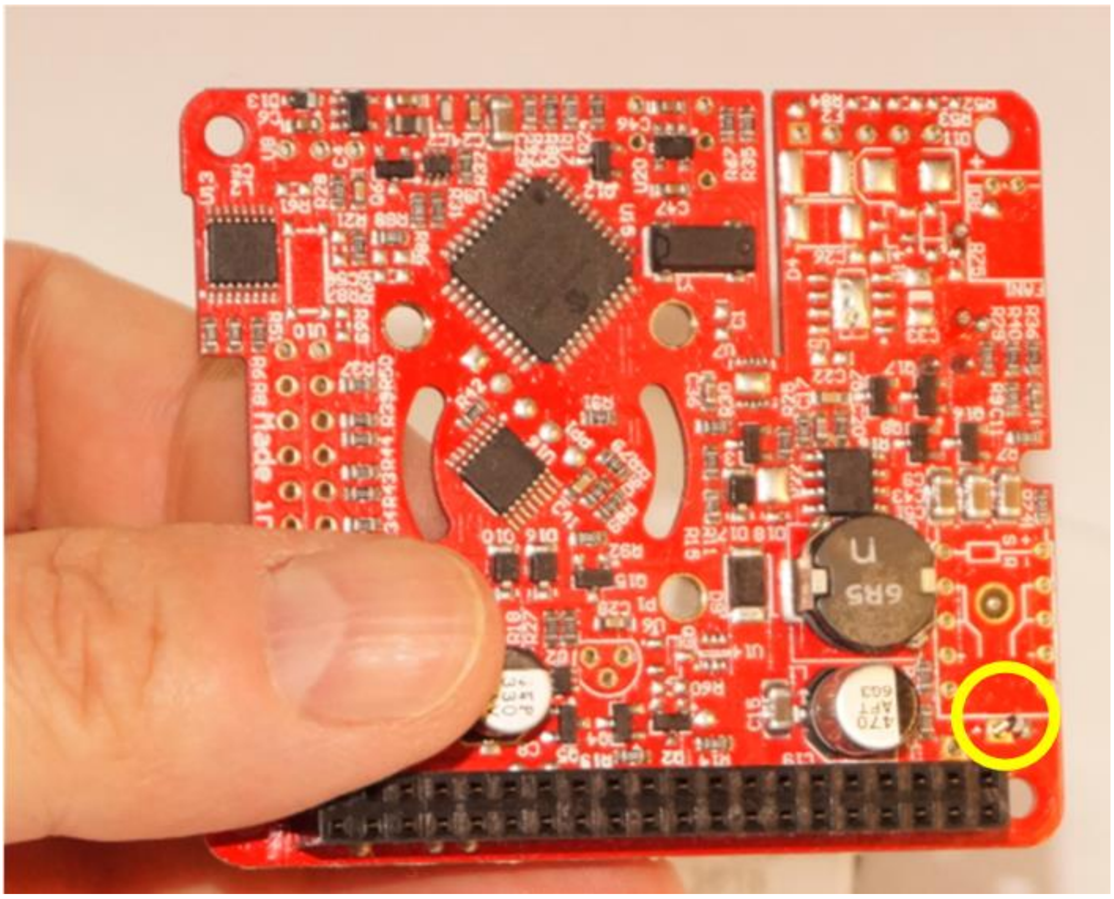


Figure 28 Gold-Plated Reset Pin on the place RPi3

Make sure to screw the poper spacers on the side where HDMI connector of the Raspberry Pi® (on the oposite side of the 40 pin connector and screw them). This will ensure that the distance between **UPS PIco HV3.0 HAT** and Raspberry Pi® is proper and provide a resistance when **UPS PIco HV3.0 HAT** buttons are pressed.

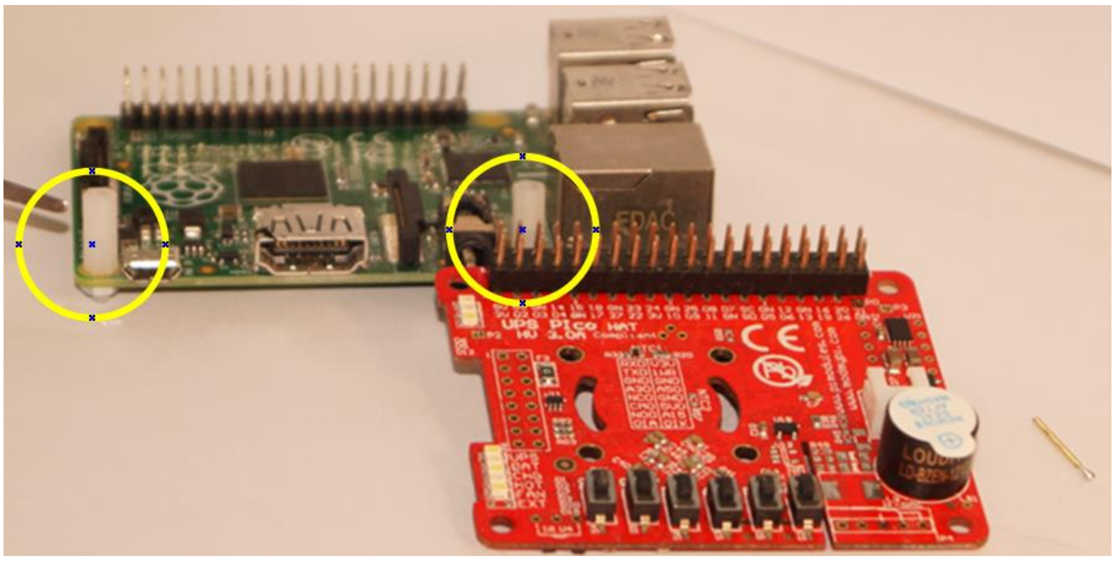


Figure 29 Spacers screwed on their places

Put the **UPS PIco HV3.0 HAT** on the Raspberry Pi®, and take care to center the head of the **Gold Plated Reset Pin** to the center of the RUN square pad hole.

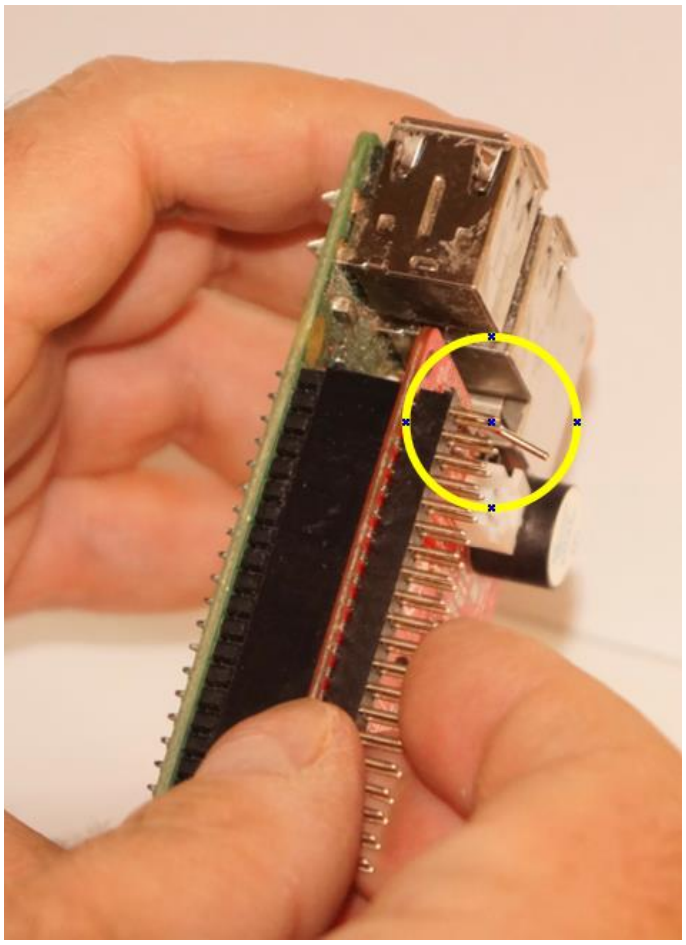


Figure 30 UPS PIco HV3.0 on the Raspberry Pi with Gold-Plated Reset Pin

Check it, by pressing the pin on the Top. Then, using a soldering tool, solder the **Gold-Plated Reset Pin** on the top of the PCB only. Take care to heat up properly the pin before you will add the tin. After soldering it will look like in the picture below. Make sure that the **Gold-Plated Reset Pin** after soldering touches properly the RUN on the Raspberry Pi®.

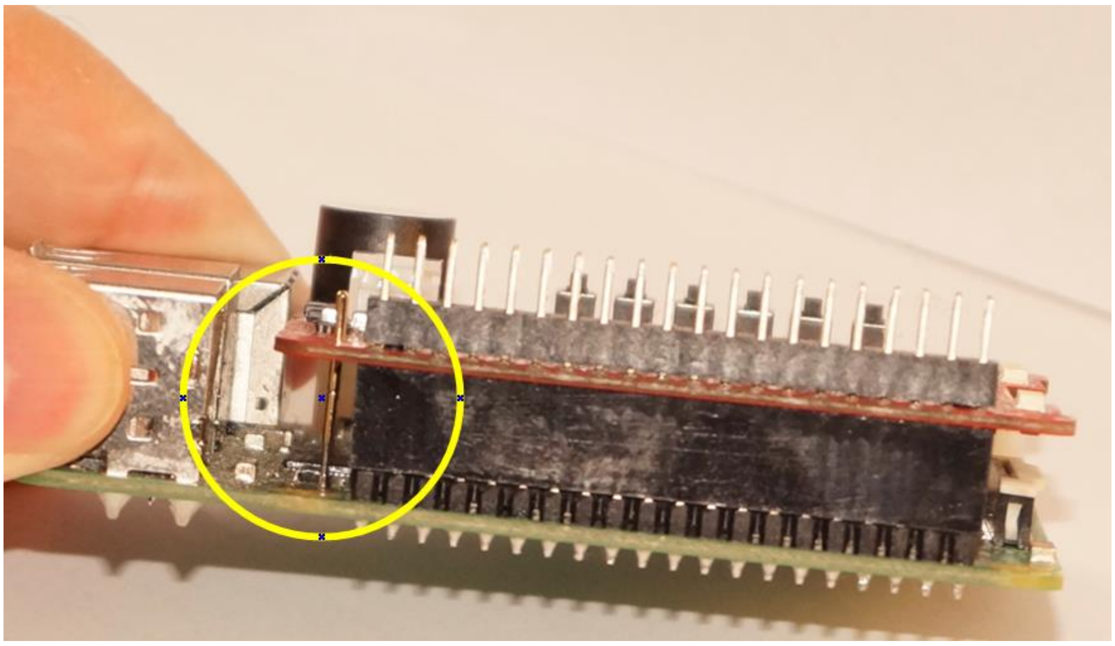


Figure 31 The Gold-Plated Reset Pin must point exactly on the hole of the RUN pad

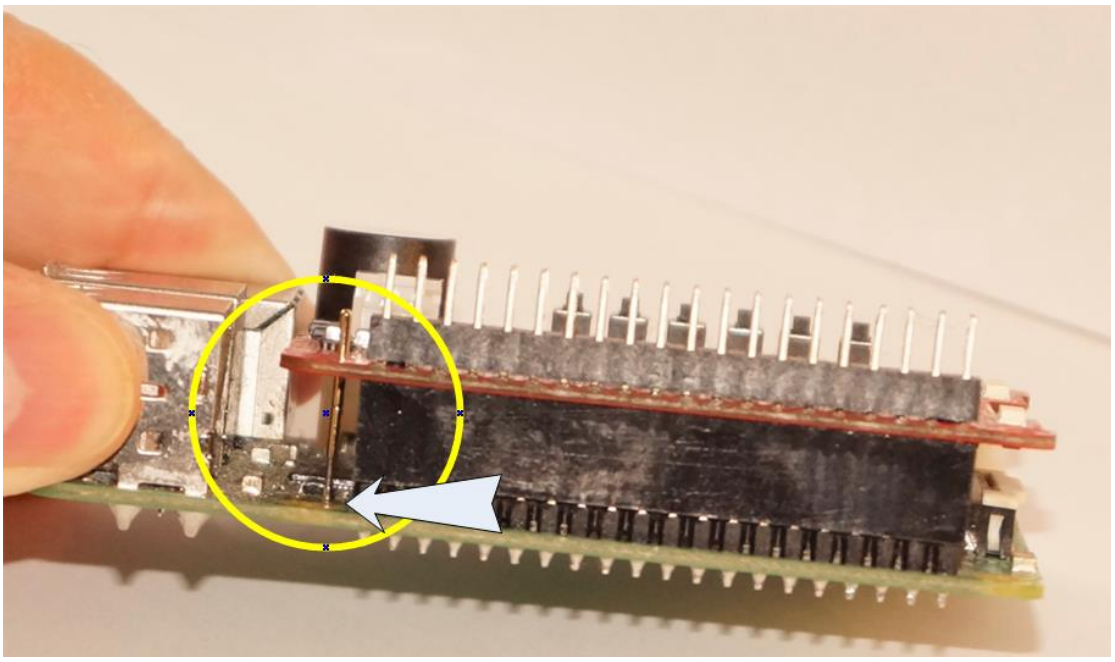


Figure 32 Pointing exactly on the hole of the RUN pad

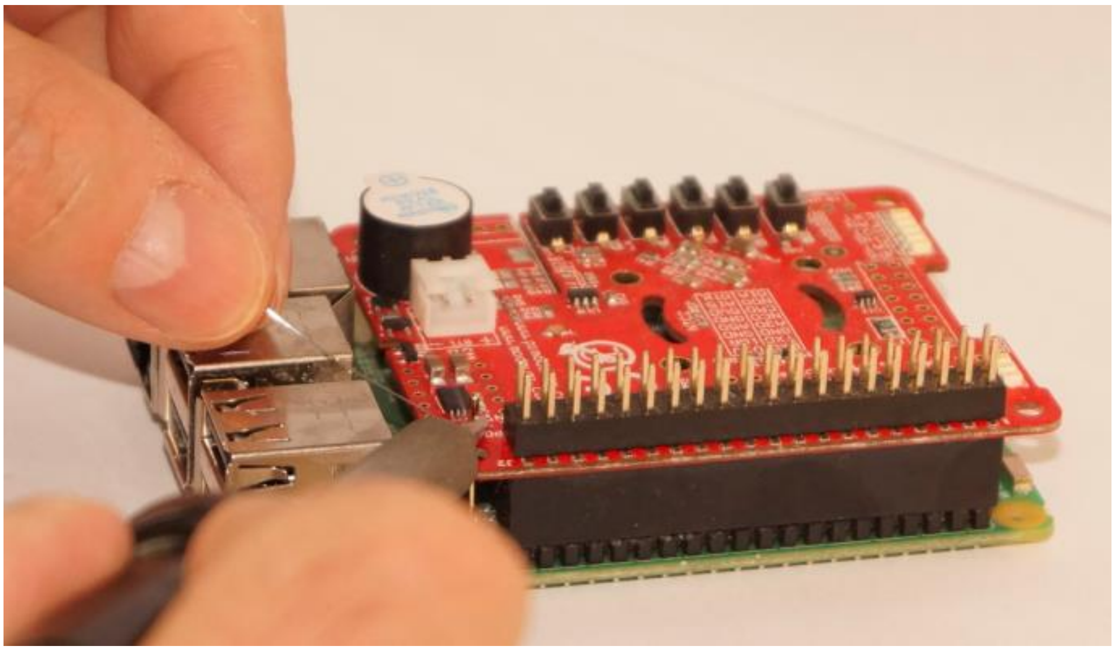


Figure 33 Soldering the Gold-Plated Reset Pin on the PIco

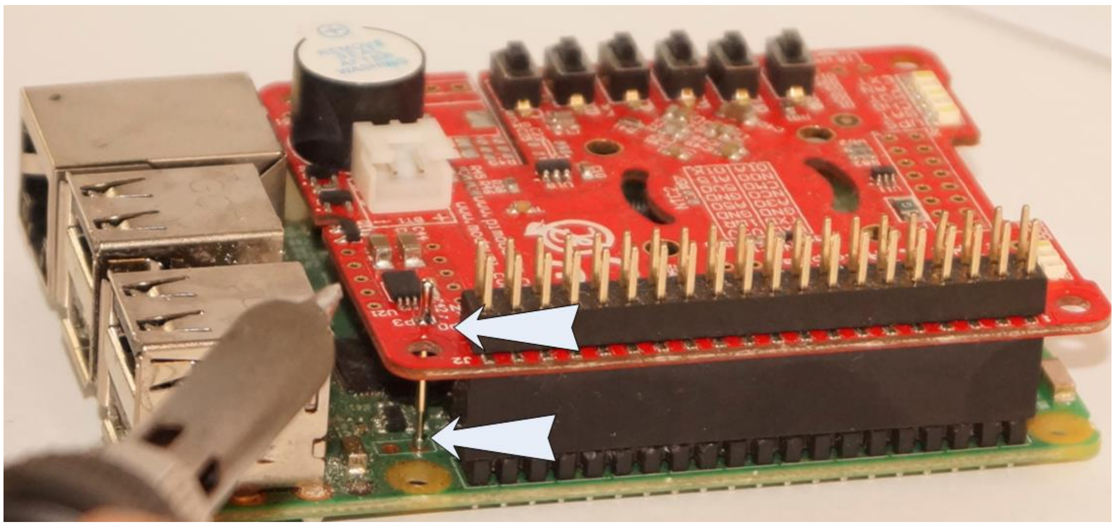


Figure 34 Soldered Gold-Plated Reset Pin is touching exactly the RUN pad

Then to make **Gold Plated Reset Pin** internal spring working, you need to re-solder it by pressing down for about 1.5 – 2 mm. Press it down with screw driver and heat up with a soldering tool. Then remove the soldering tool, keeping pressing the pin down. After about 5 seconds, you can put out the screw driver.

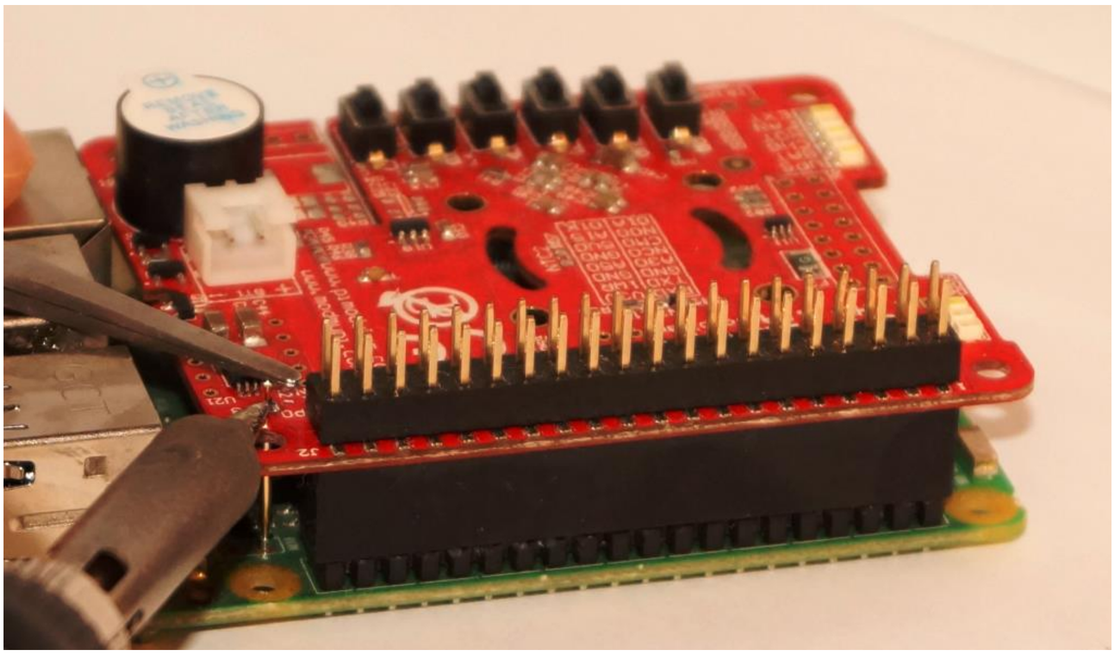


Figure 35 Heating and pressing of the Gold-Plated Reset Pin

You will make the **Gold-Plated Reset Pin** ready.

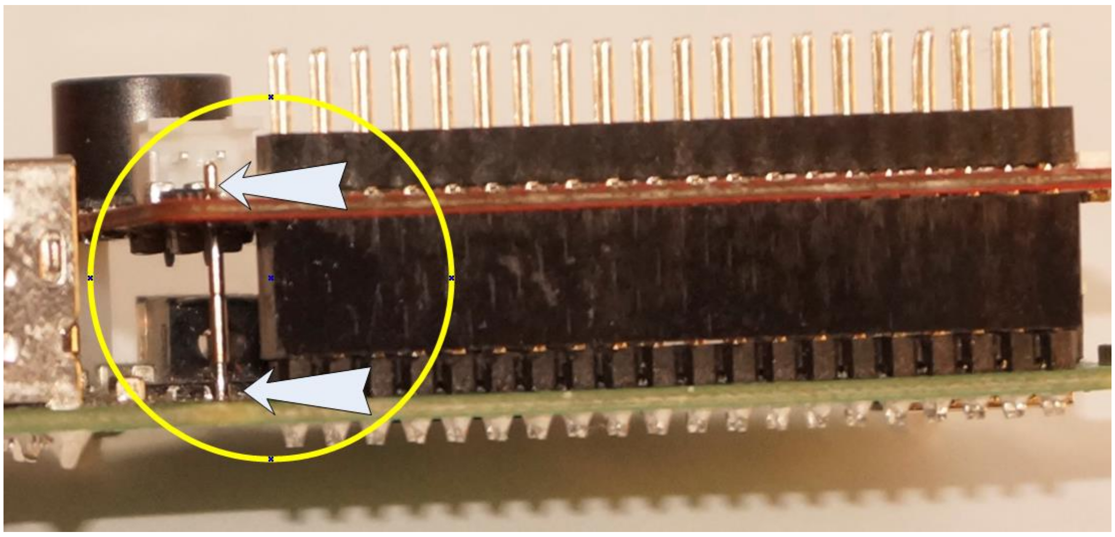


Figure 36 Gold-Plated Reset Pin properly soldered

To test it, make Raspberry Pi® working and reset it by pressing the **R** button on the **UPS PIco HV3.0 HAT.**

More advanced usage of the **Gold Plated Reset Pin** is described in another chapter.

Assembly of the Bi-Stable Relay

If you would like to install the Bi-Stable Relay kit, please do so now following the instructions below. It is not mandatory to install the Bi-Stable Relay now, but it will enable full function of the **UPS PIco HV3.0 HAT** module. User need to follow the below steps when assembling it to the **UPS PIco HV3.0 HAT** PCB.

Prepare the UPS PIco HV3.0 PCB, Bi-Stable Relay and 3 ways Terminal Block

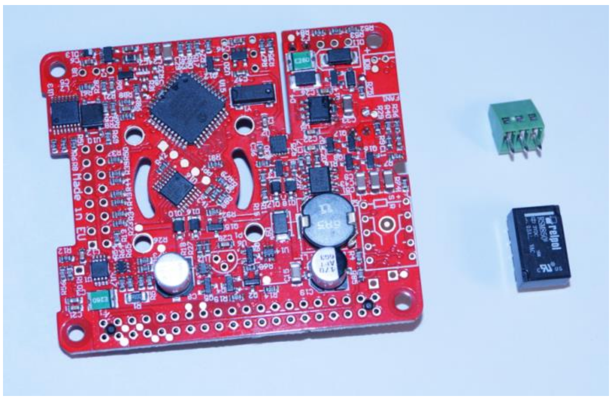


Figure 37 Ready for assembly UPS PIco HV3.0 HAT, Bi-Stable Relay and Terminal Block

Make sure that marker of the Bi Stable Relay (white bold line) and on PCB are on the same direction. It is very important because if Bi Stable Relay will be soldered in a wrong way, it is not possible (ultra-difficult) to de-solder it again and correct

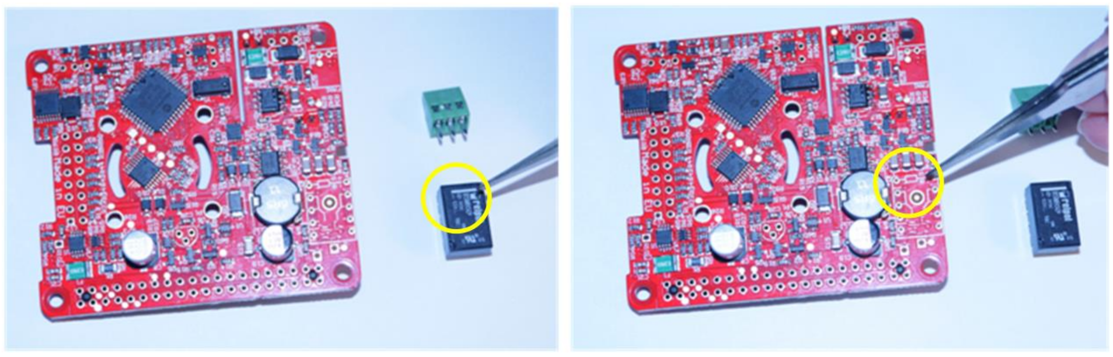


Figure 38 UPS PIco HV3.0 on Bottom Side, and Bi-Stable Relay

Put the Bi Stable Relay Pins trough the holes

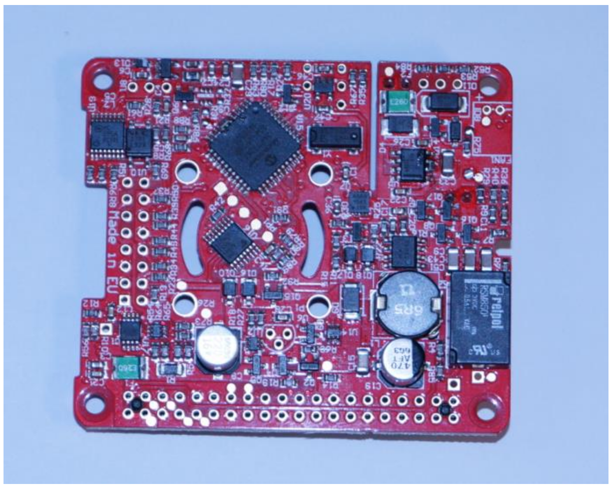


Figure 39 Put the Bi-Stable Relay on the PCB

Put the PCB with Relay to the opposite side and solder **only** one pin. It is very important to solder only one pin, as if you made a mistake it will be easy to correct it.

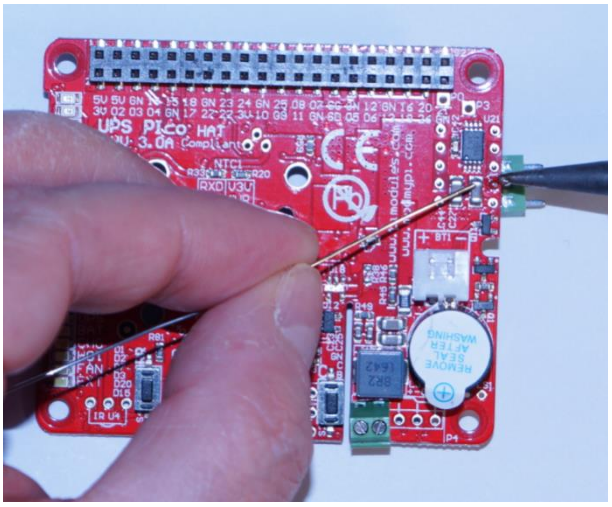


Figure 40 Soldering of one pin of the Bi-Stable Relay

Then make sure that everything (after double checking) are OK, and proceed with soldering of all other Pins.

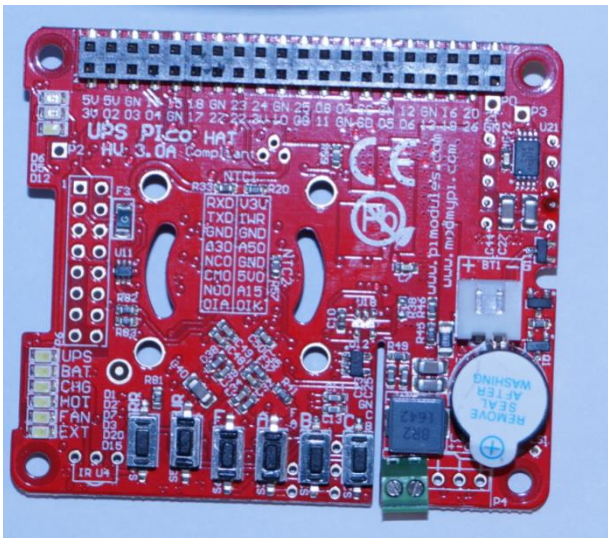


Figure 41 Soldered one pin of the Bi-Stable Relay

Solder all the rest of Bi-Stable Relay very carefully to avoid any short-cut with other near placed components.

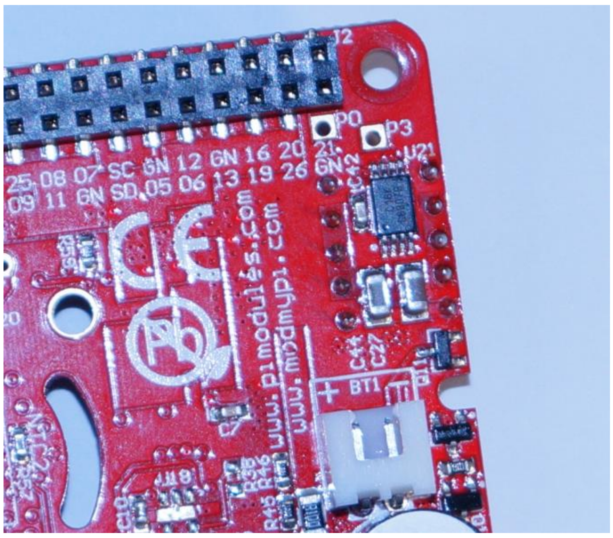


Figure 42 Completely Soldered Bi-Stable Relay

After completing of the soldering, cut the outstanding over the PCB pins (very carefully – PCB is very density!!!)

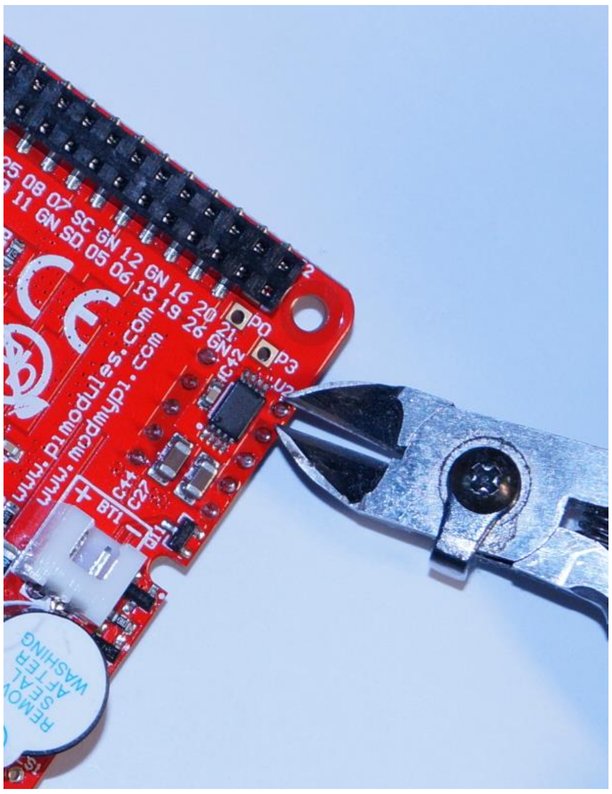


Figure 43 Cutting of the outstanding pion of the soldering Bi-Stable Relay

Prepare the 3 ways terminal block. Make sure that cables holes are in the proper side (looking outside)

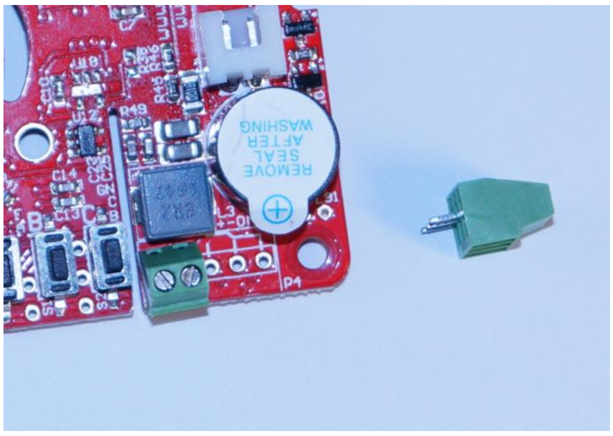


Figure 44 Terminal Blocks for the Bi-Stable

Pass the Terminal Block through the holes. Make sure that Terminal Blocks cables holes looks to the outside side.

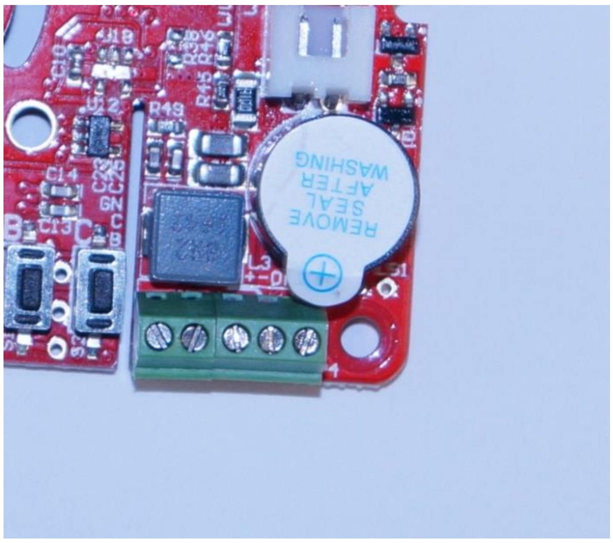


Figure 45 Terminal Block on the proper side

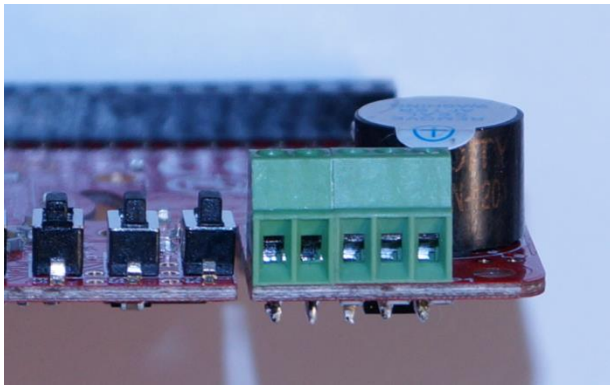


Figure 46 Soldered Terminal Blocks

Solder Terminal Block Pins and cut the outstanding legs over the PCB, be very careful with other components placed near to them (SMD Resistors).

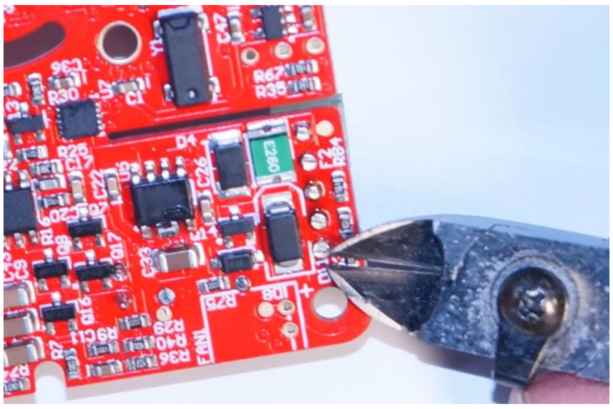


Figure 47 Cutting of the Terminal Block outstanding legs

Power Supply Unit Recommendations

Please ensure that you are using a good quality Power Supply Unit available for powering of the Raspberry Pi and **UPS PIco HV3.0 HAT**. A PSU 5V@2.5A is recommended, however for more advanced applications 5V@3.0A PSU is preferred. This will ensure that there is enough current to recharge the PIco’s battery. Low quality PSUs, or PSUs with bad quality of supply cables cause a voltage drops on the Raspberry Pi® 5V GPIOs that are recognized by the PIco and force a wrong functionality. It is also mandatory to have good quality micro USB powering cable. Please avoid PSUs that use dual USB connectors as there are double voltage drops on both USB connections (micro USB, and USB socket).

Once you have all parts correctly installed, we’re ready to proceed with software installation

Software Setup for UPS PIco HV30 Stack/TopEnd/Plus

There are a few very simple steps than need to be followed to setup the software. In any case if user cannot follow these guides, a ready SD image (8GB) is available on our forum, always with the latest NOOBS, with all software procedures installed. It can be used also as a running example on a separate SD card for debugging purposes.

There is no need to have placed the **UPS PIco HV3.0 HAT** on top of the Raspberry Pi® when installing the software, however can be also placed on top. The presence of the UPS PIco HV3.0 HAT does not affect software installation.

The software installation procedure consists the following steps that need to be executed

- Operating System Installation (Raspbian)
- Activation of I/Os (i.e. I^{2}C) as also some libraries installation
- Daemons Installation
- RTC Installation
- If needed in the future, firmware updates installation (this operation need to have installed **UPS PIco HV3.0 HAT** hardware)

Installation of the Operating System (Raspbian)

Please download and proceed with installation of the latest NOOBS or install a separate RASPBIAN on your SD card. If you like you can use also a ready to use installed image that can be downloaded directly from our forum. It consists always the latest NOOBS installed with all stuff needed included. There is also an image restore program included in the ZIP file. It can be downloaded from the following link.

http://www.forum.pimodules.com/viewtopic.php?f=30&t=4126

The installed software for interaction with the Raspberry Pi, is using the GPIOs GPIO_GEN27 and GPIO_GEN22. These GPIOs are used to send and receive pulse train to/from the Raspberry Pi. It is also used to initiate the shutdown procedure when/if it is needed. The Daemons are monitoring these GPIOs and fire-up and interrupt on the Raspberry Pi side. This approach is very flexible and does guarantee that interaction even if huge files are copied and Raspberry Pi is ultra-busy with other tasks.

Installation Procedure of Daemons and email broadcasting System

1. Install Raspberry Pi Operation System (i.e. NOOBs)

2. Enable the I^{2}C
3. Ensure that Python is installed and updated, by using the following command

```
sudo apt-get install python-rpi.gpio
```

4. Ensure to run below line

```
sudo apt-get -y install git python-dev python-serial python-smbus
python-jinja2 python-xmltodict python-psutil python-pip
```

(Take note of the line-wrapping above, it should all be on one line)

5. Note that some of the above can also be install with pip as below:

```
sudo pip install jinja2
sudo pip install xmltodict
```

(Obviously after python-pip has been installed)

6. Clone Raspberry Pi daemons and email broadcasting system from the GitHub using the following command

```
sudo git clone
```

7. Move to the required directories where software has been copied.

8. First to the email broadcasting system (package)

```
sudo cd PiModules/code/python/package
```

9. Then proceed with the installation of the email package software

```
sudo python setup.py install
```

more information about the package usage and details are available at

https://github.com/modmypi/PiModules

10. Second to the System Monitoring and File Safe Shutdown Daemons (picofssd)

```
cd ../upspico/picofssd
```

11. Then proceed with the installation of the picofssd daemons software

```
sudo python setup.py install
```

12. Once the script has been installed, it can be installed to the `SystemD` with the following command

```
sudo systemctl enable picofssd.service
```

13. Now when the Pi is rebooted the daemon should start automatically.

The Daemons can be started and stopped in the usual way for SystemD:

```
sudo systemctl start picofssd.service
```

```
sudo systemctl stop picofssd.service
```

Important Notices:

1. Both PIco packages must be installed even if not used.
2. It is very important to start/stop the Daemons Service when doing Hardware Reset of the PIco HV3.0 to avoid undefined situations with pulse train recognition procedure by the system. Resetting the PIco with Not Stopped the Daemon Service can cause an unexpected system shutdown (however without card corruption - system will just safety shutdown).

Installation Procedure of the UPS PIco HV3.0 Hardware RTC

1. Ensure to run below line

   ```
   sudo apt-get -y install i2c-tools
   ```

2. Edit by running the following line

   ```
   sudo nano /etc/modules
   ```

   and check, make sure to have the following items in the file and add what is missing:

   ```
   i2c-bcm2708
   i2c-dev
   rtc-ds1307
   ```

3. Edit by running the following line

   ```
   sudo nano /boot/config.txt
   ```

4. and add the following to this file:

   ```
   enable_uart=1
   dtoverlay=i2c-rtc,ds1307
   ```

5. Edit by running the following line

   ```
   sudo nano /etc/rc.local
   ```

6. and add the following line before “**exit 0**”

   ```
   sleep 4; hwclock -s &
   ```

7. Reboot system by

   ```
   sudo reboot
   ```

8. Remove the **fake-hwclock** which interferes with the RTC **hwclock**

   ```
   sudo apt-get -y remove fake-hwclock
   sudo update-rc.d -f fake-hwclock remove
   ```

9. Run

   ```
   sudo nano /lib/udev/hwclock-set
   ```

10. and comment out these three lines:

```
#if [ -e /run/systemd/system] ; then
# exit 0
#fi
```

11. Run **date** to verify the time is correct.

12. Plug in Ethernet or WiFi (if not plugged before) to let the Pi sync the right time from the Internet. Once that's done, run:

```
sudo hwclock -w
```

13. to write the time, and another

```
sudo hwclock -r
```

13. to read the time

That's it! Next time you boot the time will automatically be synced from the RTC module.

Automatic Installation Scripts

Two valuable users have been written an Automatic Installations Scripts that are very useful. Users that prefer to make the installation easier using them can find information here below:

1. Siewert Lameijer's located at

   http://www.forum.pimodules.com/viewtopic.php?f=27&t=4870

2. Crescendo Fang's located at

   http://www.forum.pimodules.com/viewtopic.php?f=27&t=3053

Bootloader Feature – keep the system up to date

UPS PIco HV3.0 A HAT is a very flexible hardware platform that offers a wide range of features. Most of them are software programable. Therefore, during the time, new versions with additional features are released. It is mandatory for the user, to have the ability to upload the newest firmware version whenever it is released, to keep the **UPS PIco HV3.0 A** HAT up to date. The firmware upload to the **PIco HV3.0 A** HAT is done by running a small piece of software located in dedicated memory part in the micro controller called boot sector. This memory part is protected from any erase, so even if uploading of the new firmware procedure fails, this bootloader will never fail.

The execution (the invoking) of the bootloader can be done from a software level by running of some dedicated commands, or manually by pressing of dedicated key sequence. The bootloader is equipped with additional protection mechanism called watch-dog, and if within 32 seconds from invoking of it system not start uploading the new firmware, **UPS PIco HV3.0 A** HAT will be reset, and start execution of the old already existing firmware. The bootloader functionality ensures that the **UPS PIco HV3.0 A** HAT is up-to-date, and allows users to report various changes that can be implemented on the user's side. It is extremely useful functionality, and ensures that the product has longevity.

As the bootloader uses the Raspberry Pi® Serial Port (RS232), it is mandatory to have it free on the Raspberry Pi® (without any hardware occupying it). It is also important that you ensure that there is no software using it. As well if minicom has been used, please restart the Raspberry Pi, as minicom keeps the RS232 interface occupied.

When doing the firmware upload, it is also mandatory to have the system cable powered (there is no UPS protection provided during that time) as also have stopped the Daemons to avoid any undefined conditions with used GPIOs.

Firmware updates Procedure of the UPS PIco HV3.0 (on RPi3)

Serial Port disable Procedure

To disable serial communication over the UART long enough to do a Firmware update. You need to do two things.

1. Run

   sudo nano /boot/config.txt and add this line:

   dtoverlay=pi3-disable-bt

2. Run

   sudo systemctl disable hciuart

3. Run

   sudo systemctl stop

4. Run

   sudo systemctl disable

5. You could also disable the console by removing this line from **/boot/cmdline.txt** if present, then reboot:

   console=ttyAMA0,115200

As it has been written before the **UPS PIco HV3.0 A** HAT features an embedded serial bootloader which allows users to update the unit's firmware. The firmware can be uploaded using a dedicated python script, called **9600_picofuHV3.0.py**

It is mandatory to have previously installed python and I2C-tools on the Raspberry Pi. You will install these during initial PIco setup outlined previously in this entity. Please install **smbus** support for python to enable additional functionality. Simply run the following command (with an internet connection):

sudo apt-get install python-smbus

The first task which is done by the **UPS PIco HV3.0 A** HAT after reset is to check if bootloader has been requested. If not, then the rest of the firmware runs. Otherwise, the **UPS PIco HV3.0 A** HAT lights the Orange User LED and waits for the firmware upload from the Raspberry Pi ®, and when firmware starts uploading, change from Orange User LED to Blue User LED.

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

Automatic Bootloader Initiation

Remember to have system cable powered as during the boot loading procedure system is not protected from power losses

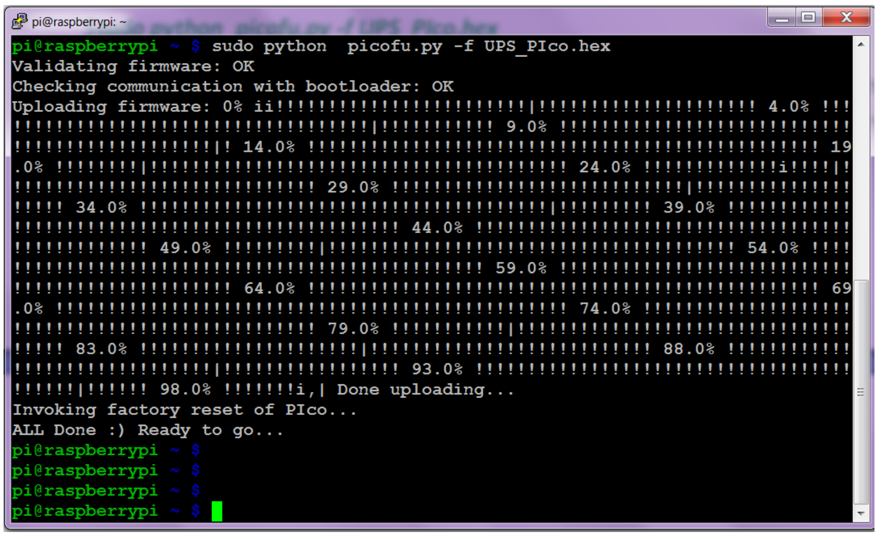
The bootloader is invoked by running the following command line:

```
sudo i2cset -y 1 0x6b 0x00 0xff

sudo python 9600_picofuHV3.0.py -v -f UPS_PIco_HV3.0_main.hex
```

The UPS_PIco_HV3.0_main.hex should be replaced with the name of the last firmware update, or the firmware you wish to use.

When firmware starts the upload procedure, the Orange User LED will have lit, and then when firmware starts uploading the Blue User LED will lit and UPS LED will be blinking.



```
pi@raspberrypi ~ $ sudo python  picofu.py -f UPS_PIco.hex
Validating firmware: OK
Checking communication with bootloader: OK
Uploading firmware: 0% ii!!!!!!!!!!!!!!!!!!!!!!!!|!!!!!!!!!!!!!!!!!!!!! 4.0% !!!
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!|!!!!!!!!!!! 9.0% !!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!!!!!!!!!!!!!!!!!|! 14.0% !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!! 19
.0% !!!!!!!!|!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!! 24.0% !!!!!!!!!!!!!i!!!!|!
!!!!!!!!!!!!!!!!!!!!!!!!!!!!! 29.0% !!!!!!!!!!!!!!!!!!!!!!!!!!!!|!!!!!!!!!!!!!!!
!!!!! 34.0% !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!|!!!!!!!!! 39.0% !!!!!!!!!!!!
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!! 44.0% !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!!!!!!!!!!! 49.0% !!!!!!!!!|!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!! 54.0% !!!!
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!! 59.0% !!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!!!!!!!!!!!!!!!!!!! 64.0% !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!! 69
.0% !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!! 74.0% !!!!!!!!!!!!!!!!!!!!
!!!!!!!!!!!!!!!!!!!!!!!!!!!!! 79.0% !!!!!!!!!!!|!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!!! 83.0% !!!!!!!!!!!!!!!!!!!!!|!!!!!!!!!!!!!!!!!!!!!!!!!!! 88.0% !!!!!!!!!!!!
!!!!!!!!!!!!!!!!!!!|!!!!!!!!!!!!!!!!! 93.0% !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!!!!|!!!!!! 98.0% !!!!!!!i,| Done uploading...
Invoking factory reset of PIco...
ALL Done :) Ready to go...
pi@raspberrypi ~ $
pi@raspberrypi ~ $
pi@raspberrypi ~ $
pi@raspberrypi ~ $
```

Figure 48 SSH screen when firmware uploading

Once complete the system with output **ALL Done :) Ready to go. . .**

We would recommend that you now shutdown your Pi and **UPS PIco HV3.0 A** HAT completely to ensure that all changes are integrated. Once you've rebooted your system, you can check the UPS PiCo firmware version using the following command:

```
sudo i2cget -y 1 0x69 0x26
```

In this case the system should output **0xXX**, signifying that the firmware has updated correctly.

Manual Bootloader Initiation

For emergency reasons (i.e. faulty upload, upload of a wrong corrupted files etc.) The **UPS PIco HV3.0 A** HAT has the ability to invoke the bootloader manually, via the on-board buttons. You can do this instead of using the automatic initiation outlined above. However, user need to have physically access to the device, as needs to push buttons.

It is very important to **stop** (before upload) and then **start** (after upload) the Daemons Services when doing Hardware Reset of the PIco HV3.0 to avoid undefined situations with pulse train recognition procedure by the system. Resetting the PIco with Not Stopped the Daemon Service can cause an unexpected system shutdown (however without card corruption). Please use the below command to stop the FSSD service

```
sudo systemctl stop picofssd.service
```

The following procedure needs to be followed:

- Press and hold the **UR** button
- Continue to hold the **UR** button, and press and hold the **F** button.
- Release the **UR** button, but keep holding the **F** button
- Release the **F** button

The Orange User LED will have lit, and system will be able to receive the firmware update

Then write the following command on the Raspberry Pi command line

```
sudo python 9600_picofuHV3.0.py -v -f UPS_PIco_HV3.0_main.hex
```

The UPS_PIco_HV3.0_main.hex should be replaced with the name of the last firmware update, or the firmware you wish to use.

If within 32 second after boot loader initiation the firmware is not start uploaded, the UPS PIco HV3.0 will be reset to normal working conditions by internal Watch Dog mechanism. This has been implemented for security reasons for remote firmware upload.

Post-Firmware Update procedure

After firmware upload some steps are needed to return the system to previous state.

Please follow below steps to do that.

Run

```
sudo nano /boot/config.txt
```

and REMOVE this line:

```
dtoverlay=pi3-disable-bt
```

Run

```
sudo systemctl enable hciuart
```

Run

```
sudo systemctl enable
```

Re-add this line to **/boot/cmdline.txt** just before **console=tty1** line:

```
console=ttyAMA0,115200
```

Then run the following:

```
sudo systemctl start picofssd.service
```

Reboot system by **sudo reboot**

Take note you should see the UPS LED blinking steady at 400ms when the OS is ready.

Using the UPS PIco HV3.0 HAT

The **UPS PIco HV3.0 HAT** is a complete and flexible cable/battery powering system, that provides also a protection from cable powering losses and save the SD card from corruption (the UPS functionality). In addition, it is offering a plenty of additional features that make it unique on the market. Compared with other similar Raspberry Pi® UPS or Powering Systems is the most advanced than any other. The usage and their capabilities will be described here below. There have been divided in following entities:

- Running the System for the first time
- System Functionality and Features
- User Applications Hardware Interfaces
- Measuring and Monitoring System
- Events Triggered RTC Based System Actions Scheduler

Running the System for the first time

Once proceeded with Hardware and Software installation, user can start using of the complete system. Ensure that **UPS PIco HV3.0 HAT** is properly placed on the Raspberry Pi® top, and spacers are screwed. Plug-in the battery to the BT1 socket (battery can be plugged/unplugged also when system is running - cable powered, however we recommend to plug-it from the beginning), and apply power to the Cable Power Inputs. They can be the Raspberry Pi® micro USB, or the EXT (7-28V DC) power, or both at the same time. **UPS PIco HV3.0 HAT** is protected with ZVD and both powering sources can be supplied at the same time without any problem.

After cable power applying Raspberry Pi® will start booting and during that time the UPS Blue LED will lit continuously. After about 30-40 seconds when Raspberry Pi® boots-up and properly installed Daemons starts running the UPS LED should be blinking about 2 times per second as far Cable Power is still. If the UPS LED is not blinking, that means the Daemons are wrong installed, and user need to check the installation process again. If the UPS LED is blinking properly remove any cable power applied and the UPS LED should be blinking much slower. These two steps ensure you that the Daemons are installed correctly and **UPS PIco HV3.0 HAT** running properly. Your system is ready and protected. If you will not apply the cable power again, after 60 seconds of running on battery, your system will be forced by **UPS PIco HV3.0 HAT** to safe shutdown. If Cable power will be applied again, your system will boots-up and start running again. This is the basic usage, and if you have recognized all stages, you are ready. Enjoy your new UPS PIco installed and protecting your system. For furthermore advanced usage you need to follow the next chapters.

System Functionality and Features

The **UPS PIco HV3.0 HAT** core functionality is to provide powering battery back-up and protect the Raspberry Pi® system from micro SD card corruption if power loss occurs during writing to micro SD card.

However, due to implementation of enhanced battery powering system it can be used for any kind of Battery or Cable Powered Application.

The **UPS PIco HV3.0 HAT** is plugged on top of the Raspberry Pi® and it is continually monitoring the GPIO 5V Pins. The proprietary implemented algorithm analyzes the powering status on these GPIO's and recognizes when cable powering is going to be lost. If so, then within 250 uS applies the Battery Back-Up power and when cable power returns release it. The **UPS PIco HV3.0 HAT** powering analyzer check the stability of the cable powering and only if it is stable for more than 3 seconds release the battery power Back-up returning to Cable powering

All functionality of the **UPS PIco HV3.0 HAT** can be monitored or changed/forced via enhanced set of System Variables (System Registers) accessed through the I^{2}C interface. This Interface is described in detail in another chapter. It is called **P**eripherals **I**^{2}C **Co**ntrol **I**nterface - the **PICo Interface** - and practically allows user to change most of system parameters via command line (if SSH or Terminal is used) or via any language interface (Python, C, etc.). Some of the System Parameters can be also monitored or changed via Raspberry Pi® using minicom® by using of the Raspberry Pi® Serial Port (if it is released for other applications) or again higher-level language interfaces.

The **PICo Interface** is occupying pre-defined (with possibility to change their location) addresses on the I^{2}C space. By default, they are **0x68**, **0x69**, **0x6A**, **0x6B**, **0x6C**, **0x6D**, **0x6E**, **0x6F**. In next chapters will be analyzed how to use of these System Registers. There are specified in the Table 7 UPS PIco HV3.0 HAT I2C addresses.

The installed software for interaction with the Raspberry Pi® (Daemons), is using the GPIOs GPIO_GEN27 (sending pulse train to the Raspberry Pi® and initiating the Safe Shutdown) and GPIO_GEN22 (replying by the Raspberry PI® to **UPS PIco HV3.0 HAT**). These GPIOs are used to send and receive pulse train to/from the Raspberry Pi. They are also used to initiate the shutdown procedure when/if it is needed. The Daemons are monitoring these GPIOs and fire-up and interrupt on the Raspberry Pi® side. This approach is very flexible and does guarantee that interaction even if huge files are copied and/or Raspberry Pi® is ultra-busy with other tasks. It is not allowed to use these GPIOs for any other Raspberry Pi® functionality.

System Cold Start, Warm Start, Default Start, and UPS LEDs behaviors

Cold Start

Cold Start is called when Cable Power is applied for the first time to the System after battery connection, the Raspberry Pi ® is starting up, and **UPS PIco HV3.0 HAT** is using all parameters stored in the internal EEPROM (default or user changed).

This start-up is called **Cold Start**, and means that System is starting up for the first time without power cycling as battery is connected for the first time.

Note: If you are doing a Cold Start, and battery is connected, as the Raspberry Pi® is protected also during the booting process, it is enough to connect cable power just for 2 seconds. The System will continue starting-up with battery power back-up (without cable power applied).

Warm Start

This is the most used, and normal type of System Start-up. It happens when System is Cable Power or FSSD button is pressed, after Safe Shutdown of the system, and **UPS PIco HV3.0 HAT**. This start-up is called **Warm Start**, and means that System is starting up from Low Power Mode (Power Cycling), RTC is running as system is battery powered and is in Low Powering Mode.

Note: If system is Warm Started, the Cable Power need to be applied for minimum 8 seconds to be recognized. This is the most used System Startup.

Default Start

When System is Cable Power user has a possibility to restore the factory defaults. To do that the following steps need to be followed:

- Press and hold the **UR** button
- Continue to hold the **UR** button, and press and hold the **C** button.
- Release the **UR** button, but keep holding the **F** button
- Release the **F** button

Ten flashes of the User LEDs will be visible (for about 5 seconds) during that time the Internal **UPS PIco HV3.0 HAT** EEPROM will erased and written with factory default values, including factory default battery. After that the system will start running normally with new (default) settings.

Battery Powering Protection

Due to shipping regulations in some countries, it is required to ship the **UPS PIco HV3.0 HAT** with battery connected, however without system to be powered. Therefore, to cover this requirement, a dedicated battery connectivity protection system has been implemented. It works in the following way:

1. When system is <u>not</u> cable powered (via Raspberry Pi ® or via External Powering) connecting of battery does not cause system powering, as connected to the **UPS PIco HV3.0 HAT** battery is in fact electrically disconnected. It has been implemented by using a high current/ultra-low resistance MOSFET switch (12 mOhm/7A) in default (hardware forced to OFF condition).

2. There is <u>no possibility</u> to start the system (even if battery remain connected to their socket) until External Cable (to Raspberry Pi® micro USB socket, or External Power to **UPS PIco HV3.0 HAT,** or GPIO 5V) Power applied.

3. Only when External Cable Power applied (to Raspberry Pi® micro USB socket, or External Power to **UPS PIco HV3.0 HAT,** or GPIO 5V) the system will be restarted with “cold start” (using the last stored setup in the EEPROM). It will remain powered (the **UPS PIco HV3.0 HAT)**, even if Raspberry Pi® is not powered, and continuously monitoring the power conditions.

4. During External Cable Power powering (to Raspberry Pi® micro USB socket, or External Power to **UPS PIco HV3.0 HAT,** or GPIO 5V), battery can be connected or disconnected by user at any time. Only if battery is connected system is offering SD card protection, and UPS functionality.

5. If user wish to disconnect electrically the battery from the system, should press the **R** button for more than 2 seconds, after system FSSD (File Safe System Shutdown) with disconnected External Cable Power powering. This will cause an electrical disconnection of the battery from the system. Note that RTC will be not working after that. Restarting system in such condition need to apply External Cable Power powering (to Raspberry Pi® micro USB socket, or External Power to **UPS PIco HV3.0 HAT**, or GPIO 5V) again.

Powering Modes

UPS PIco HV3.0 HAT functionality is based on internal firmware based **state machine**. This state machine is deciding on Powering State (called also Powering Mode) based on various parameters like powering source, battery level, current level, RTC etc. The current Powering Mode each time is stored in internal Variable and can be accessed by PICo interface over address 0x69, location 0x00.

The following Powering Modes are available:

- RPi (which consist both sub modes EPR and RPi)
- BAT (which consist both sub modes BAT and LPR)

User can at any time check the powering mode the system is from command line, or software interface, remotely or on site. The meaning is:

- 0x01 Powering from Cable (Raspberry Pi® or External)
- 0x02 Powering from Battery

Example of use

sudo i2cget -y 1 0x69 0x00

User should receive response 0x00 or 0x01.

UPS PIco HV3.0 HAT Low Powering functionality – Power Cycling

One of the most important feature is the **Power Cycling**. Power Cycling as specified before is the core firmware State Machine that is handling the whole system behaviors. The Power Cycling feature is handling the System Shutdown, Start-up as also battery charging.

The following scenarios has been implemented in the current firmware version that are covering 100% of possible cases.

Raspberry Pi® Shutdown Scenarios

The Raspberry Pi® can enter to Low Powering Mode in the following σψεναριοσ

TBC

"PIco is Running" Feature

Many users are using the Raspberry Pi® in remote places where is difficult to access the UPS LED and see it blinking. Therefore, is needed to check and confirm that **UPS PIco HV3.0A HAT** is running and protecting the Raspberry Pi®. For that reason, a dedicated PIco register has been implemented that allows remote user to proof that PIco is working properly. This register is placed on the I^{2}C address 0x69 at location 0x22. If the **UPS PIco HV3.0A HAT** is working (properly) this register value is updated every 1 millisecond. To proof that **UPS PIco HV3.0A HAT** is working need to read 2 times with time difference bigger than 1 millisecond. The read values need to be different.

Example of use

i2cget -y 1 0x69 0x22 w && i2cget -y 1 0x69 0x22 w

User should receive response like this (two different 16-bit numbers)

```
0x823f

0x8247
```

User Selectable PIco HV3.0 I2C addresses

The **UPS PIco HV3.0** interacts with Raspberry Pi® via I^{2}C interface. There is pre-selected (default) addresses that are used by **UPS PIco HV3.0A HAT**. However, user may need to change them to adopt the system to different address area in their application. In addition, the integrated Hardware RTC may be not used and the address of the 0x68 that is assigned to it, will be used by another external RTC provided by user. The **UPS PIco HV3.0** offers a mechanism that allows to change this addresses to different ones.

The following addresses are available:

- **DEFAULT** where used I2C addresses are: 0x68, 0x69, 0x6A, 0x6B, 0x6C, 0x6D, 0x6E, 0x6F
- **NO_RTC** where used I2C addresses are: 0x69, 0x6B
- **ALTERNATE** where used I2C addresses are: 0x58, 0x59, 0x5A, 0x5B, 0x5C, 0x5D, 0x5E, 0x5F

Addresses DEFAULT	**Addresses NO_RTC**	**Addresses ALTERNATE**	**Address Usage**
0x68	not used	0x58	Used for UPS PIco HV3.0 Hardware RTC. If RTC is activated in the Raspberry Pi will be visible as UU
0x69	0x69	0x59	Used for system monitoring
0x6A	not used	0x5A	Contains RTC registered accessible independently by user
0x6B	0x6B	0x5B	Used
0x6C	not used	0x5C	Used for the RTC Scheduler

0x6D	not used	0x5D	Used for the RTC Scheduler
0x6E	not used	0x5E	Used for the RTC Scheduler
0x6F	not used	0x5F	Used for the RTC Scheduler

Table 8 UPS PIco HV3.0 HAT I2C addresses

Any changes of the I^{2}C addresses should be preceded only when system is cable powered as changing of these addresses cause UPS PIco HV3.0 reset.

Changes of the I^{2}C are executed through the **0x6B** register number **0x00** called **pico_state**. If system I2C addresses are moved to the ALTERNATE address, then please use the **0x5B** (instead of the 0x6B) and register number **0x00** (**pico_state**).

The writing codes are the following:

- **DEFAULT -** 0xA0
- **NO_RTC -** 0xA1
- **ALTERNATE -** 0xA2

Example of use – System is in DEFAULT addresses

sudo i2cset -y 1 0x6b 0x00 0xA1 Set the System to NO_RTC mode

sudo i2cset -y 1 0x6b 0x00 0xA2 Set the System to ALTERNATE mode

Example of use – System is in ALTERNATE addresses

sudo i2cset -y 1 0x5b 0x00 0xA1 Set the System to NO_RTC mode

sudo i2cset -y 1 0x5b 0x00 0xA0 *Set the System to DEFAULT mode*

UPS PIco HV3.0 HAT Still Alive (STA) Functionality

The **UPS PIco HV3.0 HAT**, offers to the user a protection mechanism for the possibility of the Raspberry Hang-up (freeze of it). In a case that Raspberry Pi® freeze, the **UPS PIco HV3.0 HAT**, will automatically hardware reset it, using Gold Plated Reset Pin (POGO Pin) that must be soldered to have such functionality. The default state is that Still Alive functionality is disabled.

The Still Alive functionality is based on 8-bit timer located at address **0x6b** and position **0x05** that his value is decreasing every second when his value is different from 0xff. If it reaches 0x00 **UPS PIco HV3.0 HAT** resets hardware the Raspberry Pi®. The default value after restart/start of the **UPS PIco HV3.0 HAT** is 0xff (disabled).

To activate it, user need to write to this register value different than 0xff, and rewrite new value every defined time (by its written value).

The following options are available, and can be used at any time:

- Writing of 0xff cause disable of this STA timer
- Writing of 0x01 – 0xfe cause start of down counting (every second) of this STA timer until it reaches the 0x00 when the Raspberry Pi® will be hardware Reset
- Writing of 0x00 cause immediate and unconditional Raspberry Pi® hardware Reset

Example of use

sudo i2cset -y 1 0x6b 0x05 0x00 unconditional resets the Raspberry Pi®

sudo i2cset -y 1 0x6b 0x05 0x0f Sets the STA timer to 15 seconds (if within 15 seconds software running on Raspberry Pi® not write new values, Raspberry Pi® will be hardware reset by PIco.

sudo i2cset -y 1 0x6b 0x05 0xff disable the STA timer

UPS PIco HV3.0 HAT User Applications Hardware Interfaces

The **UPS Pico HV3.0 HAT** is equipped with a set of User Applications Hardware Interfaces that allows to rapid setting-up of various applications without necessity of other additional HAT PCBs. It contains:

- System and User LEDs
- System and User Buttons
- Sound Generation System
- Bi-Stable Relay
- Auxiliary 5V@750mA and 3.3V@150mA interface
- IR Receiver Interface
- Programmable RS232 Interface
- User Selectable PIco HV3.0 I^{2}C addresses (NORMAL, NO_RTC, ALTERNATE)
- ESD protected 1-wire Interface
- Opto Coupler

UPS PIco HV3.0 HAT LEDs

The **UPS Pico HV3.0 HAT** is equipped with 6 LEDs (that offers information about the **UPS Pico HV3.0 HAT** system status. Three of them are dedicated for user applications and can be handled by the **PICo** (I^2C) interface. One of them is **Orange**, the second one is **Green**, and the third is **Blue.** A detailed description of the system LEDs and their usage is provided on below table.

System LEDs Indications		
UPS LED		
	OFF	System is not running or is in Low Power Mode (only HW RTC is running)
	Lighting continuously	System (PIco + RPi) is booting or shutting down
	Blinking every 400 ms for 400 ms	System (PIco + RPi) is running on cable powering (after booting time)
	Blinking every 1200 ms for 400 ms	System (PIco + RPi) is running on battery powering
BAT LED		
	OFF	Battery level is **above** warning thresholds: - For LiPO Battery **3.6V** - For LiFePO4 **2.95V**
	Lighting continuously	Battery level is **below** warning thresholds: - For LiPO Battery **3.6V** - For LiFePO4 **2.95V**
CHG LED		
	OFF	Battery is not Charged
	Lighting continuously	Battery is Charged (and current is flowing to the battery) If battery is Full, even if Charger is ON, current is not flowing to the battery, so CHG LED is OFF
HOT LED		
FAN LED		
	OFF	FAN is not running
	Lighting continuously	FAN is running
EXT LED		
	OFF	External Cable powering is disconnected (7-28VDC)
	Lighting continuously	External Cable powering is connected (7-28VDC)

Table 9 **System LEDs description**

Accessing of the User LEDs can be done by the following **PICo** Commands.

Example of use

sudo i2cset -y 1 0x6b 0x09 0x01 for ON the Orange LED

sudo i2cset -y 1 0x6b 0x09 0x00 for OFF the Orange LED

sudo i2cset -y 1 0x6b 0x0A 0x01 for ON the Green LED

sudo i2cset -y 1 0x6b 0x0A 0x00 for OFF the Green LED

sudo i2cset -y 1 0x6b 0x0b 0x01 for ON the Blue LED

sudo i2cset -y 1 0x6b 0x0b 0x00 for OFF the Blue LED

0x09	User LED Orange	Byte	Common	R/W	User LED Orange **ON - Write:** 0x01 User LED Orange **OFF - Write:** 0x00
0x0A	User LED Green	Byte	Common	R/W	User LED Green **ON - Write:** 0x01 User LED Green **OFF - Write:** 0x00
0x0B	User LED Blue	Byte	Common	R/W	User LED Blue **ON - Write:** 0x01 User LED Blue **OFF - Write:** 0x00

Table 10 **User LEDs Commands Specifications**

UPS PIco HV3.0 A Buttons

The **UPS Pico HV3.0 HAT** is equipped with 6 buttons that can be used in various ways. Three of them are dedicated for user applications and can be handled by user through the **PICo** (I^2C) interface or **@commands** (RS232) system, all other are specific for various **UPS Pico HV3.0 HAT** functionalities. All of them can be used for some start-up functionalities when **UPS Pico HV3.0 HAT** is reset. A detailed description of all buttons and their usage is provided on below table.

It is very important to start/stop the Daemons Service when doing Hardware Reset (UR) of the PIco HV3.0 HAT in order to avoid undefined situations with pulse train recognition procedure by the system. Resetting the PIco with Not Stopped the Daemon Service can cause an unexpected system safe shutdown (however without card corruption)

Button	Description	Usage	Additional Functionalities
RR	**R**aspberry Pi® Hardware **R**eset	Make Raspberry Pi Hardware Reset when pressed. To be used need installed (soldered) the Gold Plated Reset Pin. **NOTE1**: Resetting of the Raspberry Pi®, can corrupt files on the SD card if used **NOTE2**: Resetting of the Raspberry Pi®, does **not** affect the **UPS PIco** (including PIco RTC)	NONE
UR	**U**PS Pico HV3.0 HAT Hardware **R**eset	Make the **UPS Pico HV3.0 HAT** Hardware Reset when pressed. **NOTE1**: Resetting of the **UPS PIco** does not reset the Raspberry Pi® **only** if cable powered. **NOTE2**: Resetting of the **UPS PIco** does **NOT reset** the Integrated Hardware RTC.	When pressed with combination with other buttons activate various start-up functionalities. The procedure is to press first the **UR** button, and then another one, then release the **UPSR** button and then release the other button (**A, B, C**).

F	File Safe Shut Down (FSSD)	When pressed initiate the File Safe Shutdown Procedure. If Raspberry Pi® + **UPS Pico HV3.0 HAT** system is battery powered, after FSSD finished **UPS Pico HV3.0 HAT** will cut the power. Pressed again (need to have installed the Gold Plated Reset Pin for the restart option), start the Raspberry Pi® + **UPS Pico HV3.0 HAT** system again. In the battery powered System can be used as ON/OFF (files safe) button	When used with **UR** button, invokes the bootloader (light the Red User LED). The bootloader can be invoked also from the PICo interface.
A	**User Key A**	Can be used for User Application – Read the status via PICo (I^2C) or RS232 interface	NONE
B	**User Key B**	Can be used for User Application – Read the status via PICo (I^2C) or RS232 interface	When used with **UR** button, Set the **Hardware RTC** to default values
C	**User Key C**	Can be used for User Application – Read the status via PICo (I^2C) or RS232 interface	When used with **UR** button, sets system default values.

Table 11 UPS PIco HV3.0A Buttons

User Buttons (Keys)

User buttons **A**, **B** and **C** in the **UPS Pico HV3.0 HAT** are analog buttons, that means when pressed change the level voltage that is read by integrated A/D converter, value of it is interpreted by the firmware and the result is loaded to a proper system variable and can be read by user. The **F** button is a digital interrupt driven button and his value can not be read by the user

Each User Key and **FSSD** Key (buttons) has an additional THT pads that allows to be used by user for their own mounted buttons outside of the **UPS PIcoHV3.0 HAT or case**. Each of such user added buttons (keys) need just short to the system ground when pressed**.**

Reading of User Buttons values can be done by accessing the system variable by any software or by command line.

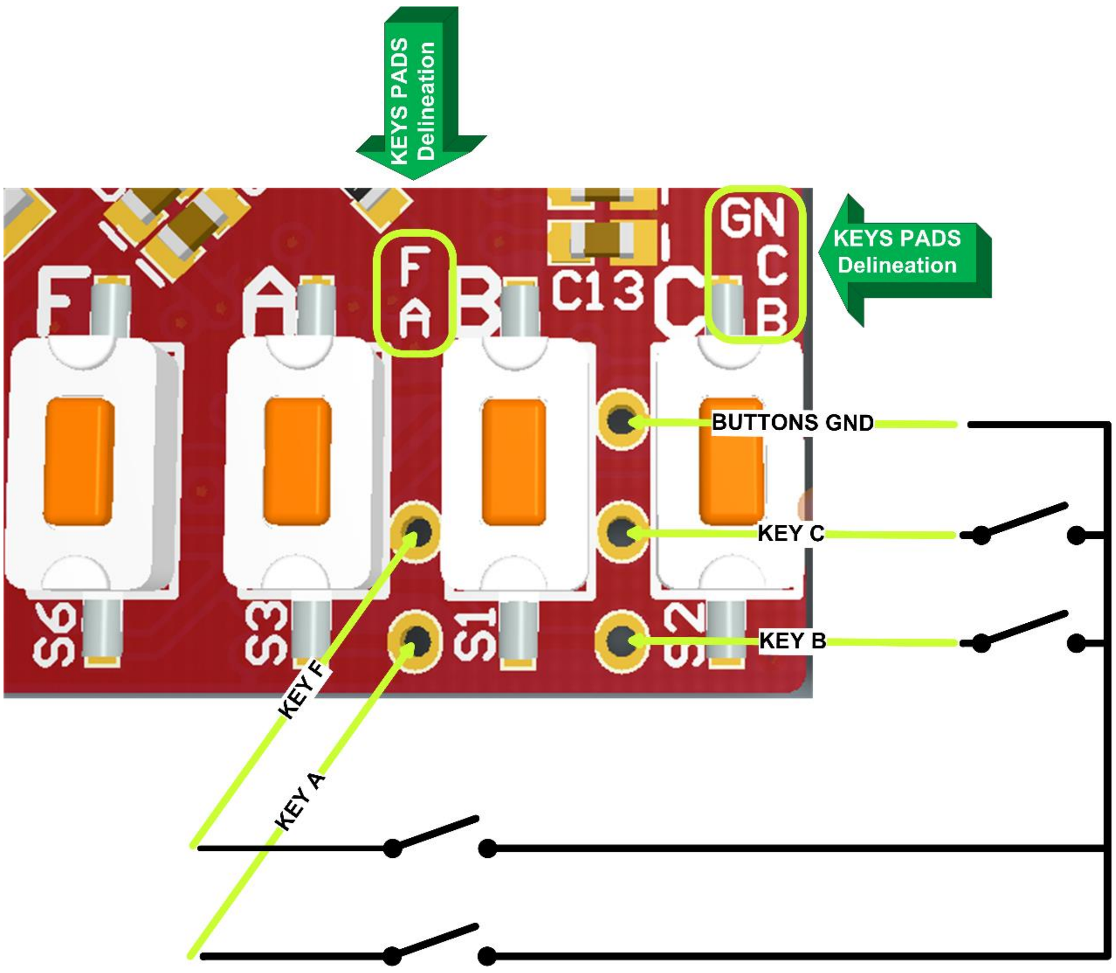


Figure 49 UPS PIco HV3.0A External Connectivity

To make working external keys (buttons), user need to solder cables to the THT key pads. It is not recommended to use a very long cable (due to analog implementation of the keyboard), their length should not be longer than 100 – 150 mm. However, we never tested longer cable and if user need to use longer cables should test it on their site. To make external keys workable user need to short each one with **GN THT** pad when pressed. In example if user need to have external access to the FSSD **(F)** button, need to install button that short the **F** pad with the **GN** pad when pressed. Similar approach should be followed with other keys. Above picture show how external key (buttons) need to be connected. It is not needed to connect all of them.

The **key** register holds the latest value of pressed key, so user need to write i.e. **0x00** after reading, to recognize that new key has been pressed (when pressed again, even the same key). Current implementation requires timed (pooling) reading of this register to recognize that a key has been pressed. In the future, it is planned to implement interrupt driven handler for this and other functionalities.

Example of use

sudo i2cget -y 1 0x69 0x1A should return 1, 2 or 3

The pressed key value will remain in the register until new value will be written when key (new one or the same) will be pressed. Therefore, user should write zero to this register after reading to recognize and read again the new (or the same) key if (when) pressed.

sudo i2cset -y 1 0x69 0x1A 0x00

UPS PIco HV3.0 HAT Sound Generation System

The **UPS PIco HV3.0 HAT** is equipped with Enhanced Sound Generation System. It is providing a user interface on various states of UPS **PIco HV3.0 HAT** conditions, but it is also available for dedicated user applications offering the whole range of acoustic frequencies full programmable by user.

There are 2 registers that are responsible for the generating sound **bfreq** and **bdur**. To generate sound user, need to program first the required frequency and then the required duration is 10th of ms.

Current implementation need to program one be one sound when generated. The maximum duration is 255 x 10 ms = 2.55 seconds

Additionally, it is possible to deactivate it permanently, by setting the bmode register to 0x00.

The default value is active

0x0D	bmode	Byte	Common	R/W	**Integrated Sounder Mode** **Read:** Anytime, Return actual **bmode** value **Write:** 0x00 – Unconditional Disable the Sounder **Write:** 0x01 – Unconditional Enable the Sounder **Default Value:** 0x01
0x0E	bfreq	Word	Common	R/W	**Frequency of sound in Hz**
0x10	bdur	Byte	Common	R/W	**Duration of sound in 10th of ms (10 = 100 ms)**

Example of use

sudo i2cset -y 1 0x6D 0x00 Deactivate permanently the buzzer (no sunds wil be played)

sudo i2cset -y 1 0x6D 0x01 Activate permanently the buzzer (default value)

In order to play sound buzzer need to be activated firstly.

sudo i2cset -y 1 0x6B 0x0e 1047 w Set the frequency to C (1047 Hz) note

sudo i2cset -y 1 0x6B 0x10 100 Set the duration to 1 second

After Sound execution, the **bdur** register is 0 again.

UPS PIco HV3.0 Bi Stable Relay

The **UPS PIco HV3.0 HAT** can be equipped with Bi Stable Relay with single coil. This Relay is standard offered with version UPS PIco HV3.0 HAT Plus, it can be also ordered separately and added to the UPS PIco HV3.0 HAT Stack/TopEnd. In both cases this Relays is not mounted on the PCB and user need to do it by himself. The assembly (soldering) of the Bi Stable Relay on the UPS PIco HV3.0 HAT PCB it is very easy task and can be done by anybody using simple soldering iron. However it is also possible that this assembling can be ordered to be done by us, if customer order directly on the eshop or any other eshop that offer such service.

The main benefit of the Bi Stable Relay is the power consumption. The Bi Stable Relays consume power only when switching from one state to another. All other times are not consuming power at all. So, we called it Zero Power Relay. Driving of such relays are little bit more complicated than the usual ones, however user not need to care about that as electrical drivers are assembled on and offered with each UPS PIco HV3.0 HAT PCB. Each Bi-Stable Relay does not have states **NO** (Normal Open) or **NC** (Normal Close), it has **Reset** and **Set** state instead. By switching of the Bi Stable Relay, user changes the state from **Reset** to **Set** and vice versa. User should know that If Bi Stable Relay change their status **Reset/Set** will stay on it (also when power will be completely removed) until new switch commend will be send. If Bi Stable Relay receives one command **Reset** or **Set**, sending multiple times of the same will not change anything. To change status must be send opposite one i.e. if s **Reset**, the opposite one is **Set**.

Bi Stable Relay Contact description	**Meaning**
Normally Close Output (on Set State)	On Set State this contact is closed and have connection with Common. Similar to the “normal” Relay NC (Normal Close)
Common Output (on Reset/Set State)	On Reset/Set States this contact is switching between NCO/NOO
Normally Open Output(on Set State)	On Set State this contact is Open and does not have connection with Common. Similar to the “normal” Relay NO (Normal Open)

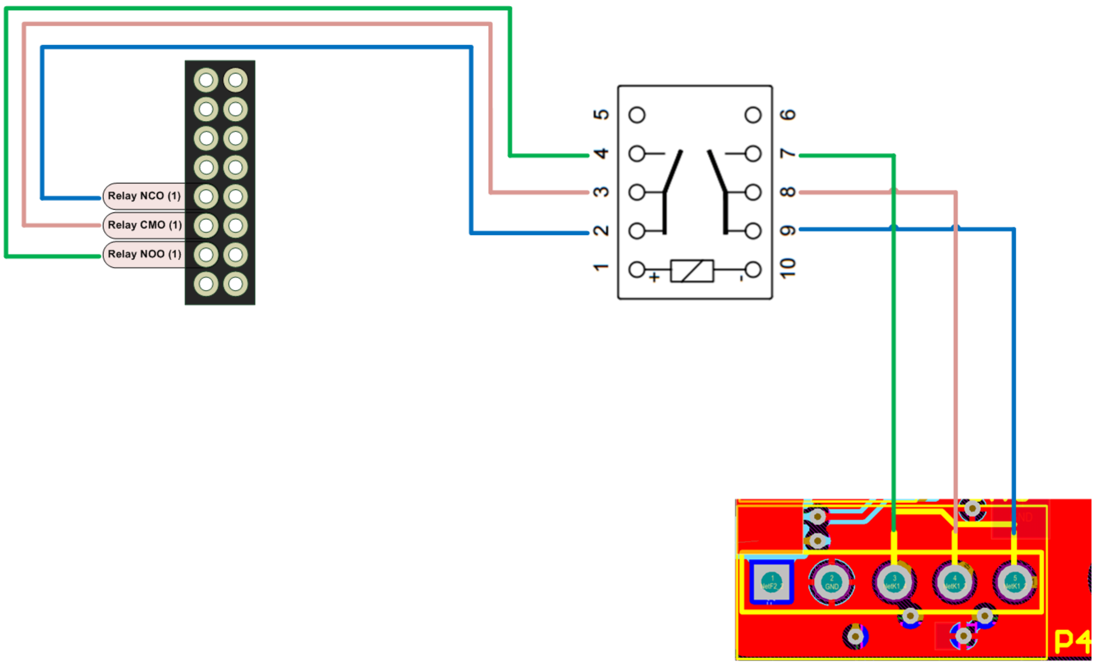
Bi Stable Relay Basic Technical Specifications

Arrangement	2 form C (DPDT)

Contacts Material	Gold overlay silver alloy
Contacts Resistance (initial)	Maximum 50 mΩ (at 1 A 6 VDC)
Contacts Rating (resistive)	0.5 A 125 VAC or 1 A 30 VDC
Contacts Maximum Carrying Current	2 A
Contacts Maximum Switching Power	62.5 AV/30 W
Contacts Maximum Switching Voltage	250 VAC, 220 VDC
Contacts Operate (at nominal voltage)	Maximum 6 ms
Contacts Release (at nominal voltage)	Maximum 4 ms

Due to construction of UPS **PIco HV3.0 PCB** we do not recommend to use Integrated Bi Stable Relay for switching of higher voltages/currents other than **32 VDC/1A** per switching contacts. The Integrated Bi Stable Relay contain a pair of independent switching contacts that can be used separated for 2 different and independent switching devices or connected in parallel if higher current (double) is needed.

Due to PCB construction It is absolutely not allowed to use the Integrated Bi Stable Relay for switching 220 V AC at any current, even very low.



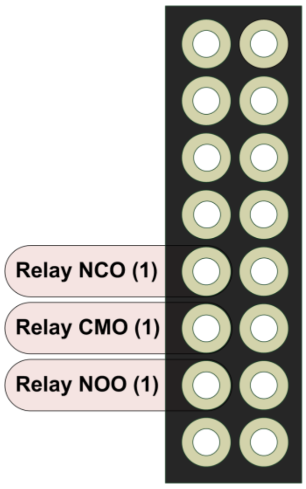
Example of use

sudo i2cset -y 1 0x6B 0x0c 0x00 should Reset the Bi Stable Relay

sudo i2cset -y 1 0x6B 0x0c 0x01 should Set the Bi Stable Relay

Each time when Bi Stable Relay is changing his state a characteristic “**tick”** is audible. Multiple execution of the same command is not changing anything.

0x0C	brelay	Byte	Common	R/W	**Zero Power Bi Stable Relay** **Write:** 0x01 Set **Write:** 0x00 Reset



UPS Pico HV3.0 HAT IR Receiver Interface

TBC

UPS Pico HV3.0 HAT Programmable Auxiliary 5V@750 mA and 3.3V@150 mA Interface

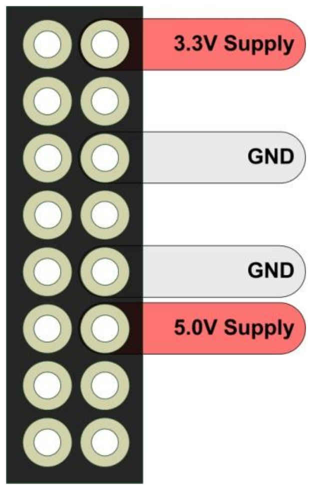
The **UPS PIco HV3.0 HAT** is equipped with Auxiliary and **3.3V@150mA** supply that are independent from the 5V of the Raspberry Pi®. There are programmable and battery backed up (if programmed by user), provide continuously supply even if Raspberry Pi® is switched off. The Auxiliary **5V@750mA** is over current protected with PPTC fuse on the **5V@750mA** as also reverse current draw with Schottky diode. Therefore, due to small voltage drop the final voltage is about 4.85V, instead of the 5.0V. The **3.3V@150mA** is only protected with LDO embedded over current protection. These Auxiliary and **3.3V@150mA** are addressed to supply devices that need to be running even if Raspberry Pi® is switched off i.e. USB HUB, PIR Sensor, additional external high current relay, Add on PCBs with extra hardware etc.

0x06	enable5V	Byte	Common	R/W	Defines usage of the Auxiliary 5V@750mA: 0x00 – Auxiliary 5V and 3.3V are not battery backed-up 0x01 – Auxiliary 5V and 3.3V are battery backed-up **Default Values is OFF** **Other codes are not allowed**

Example of use

***sudo i2cset -y 1 0x6B 0x06 0x00* the Auxiliary 5V and 3.3V will be not battery backed-up and stop working when power will be cut-off on the GPIO**

***sudo i2cset -y 1 0x6B 0x06 0x01* the Auxiliary 5V and 3.3V will be battery backed-up and will continue supply also when 5V will be not available on the GPIO**


3.3V Supply
GND
GND
5.0V Supply

UPS PIco HV3.0 Serial Port(s)

The **UPS PIco HV3.0** is equipped with 2 serial ports. One of them is connected directly to the Raspberry Pi ® Serial Port, and the second one is available for user applications. Both Serial Ports are full programmable and the data rate can be set by user, as also can be enabled or disabled. In addition, there is an internal routing option where one port can receive and send data over the other one. This allows connecting the Raspberry Pi® serial port to the external RS232 12V interface (via Terminals Blocks PCB) or to 5V tolerant without any additional Jumpers or Cables. In addition the second Serial port of the **UPS PIco HV3.0** can be used as a second serial port routed directly to the I2C interface (this option is not unlocked yet, and will be available within one of the next firmware update). The **UPS PIco HV3.0** by default is set OFF and Raspberry Pi® Serial port can be used for any other applications. If it is needed it can be set ON, as also the set the data rate. Setting the data rate sets it for both **UPS PIco HV3.0** serial ports.

After any firmware update the **UPS PIco HV3.0** Serial Ports(s) must be set again. It is done via PIco variable **rs232_rate**. The following settings are available:

Setting Value	Meaning
0x00	**UPS PIco HV3.0** Serial Port is **OFF** **Default value**
0x01	**UPS PIco HV3.0** Serial Port is **ON** and data rate is set to **4800** pbs
0x02	**UPS PIco HV3.0** Serial Port is **ON** and data rate is set to **9600** pbs
0x03	**UPS PIco HV3.0** Serial Port is **ON** and data rate is set to **19200** pbs
0x04	**UPS PIco HV3.0** Serial Port is **ON** and data rate is set to **38400** pbs
0x05	**UPS PIco HV3.0** Serial Port is **ON** and data rate is set to **57600** pbs
0x0F	**UPS PIco HV3.0** Serial Port is **ON** and data rate is set to **115200** pbs

Example of use

sudo i2cset -y 1 0x6b 0x02 0x00 ***Disable PIco RS232 and set tri state the TXD and RXD pins***

sudo i2cset -y 1 0x6b 0x02 0x05 ***Enable the PIco RS232 and set the data rate to 57600 bps***

sudo i2cset -y 1 0x6b 0x02 0x0F ***Enable the PIco RS232 and set the data rate to 115200 bps***

UPS PIco HV3.0 FAN Control (Active Cooling System)

The UPS PIco HV3.0 can be equipped with Active Cooling System based on micro FAN and dedicated temperature sensor. The PIco FAN is full PWM controlled rotation speed from 0% up to 100%. It can be manually set ON or OFF on per-selected speed, as also automatically based on preset temperature threshold. It can be done via the following registers placed at the I^2C address 0x6b (0x11, 0x12, 0x13).

0x11	fmode	Byte	Common	R/W	**Integrated Fan Running Mode** **Read:** Anytime, Return actual **fmode** value **Write:** 0x00 – Unconditional Disable the FAN with selected speed from the **fspeed** **Write:** 0x01 – Unconditional Enable the FAN FAN with selected speed from the **fspeed** **Write:** 0x02 – Automatic ON/OFF with defined speed in the fspeed, ON when temperature read in sensor T0-92 is higher than **fttemp** threshold, OFF when lower. Default value is set to 0x02 – Automatic ON/OFF **When written 0x02 to this register data are stored in the internal EEPROM. So, even if UPS PIco HV3.0 will be reset, automatic setup will be recovered. All other data (0x00, or 0x01) are not stored in the internal EEPROM.** **When UPS PIco is going down to the LPR mode, the FAN is automatically disabled, and enabled again when the UPS PIco returns to normal work**
0x12	fspeed	Byte	Common	R/W	**Integrated Fan Speed** **Read:** Anytime, Return actual **fspeed** value **Write:** 00 – Selected speed when OFF is 0% (not running) **Write:** 100 – Selected speed when ON is 100% (full speed running) **Any other (0-100) number is allowed and means % of speed and current consumption** Default speed is set to 50% **Any data written to this register are stored in the internal EEPROM. So, even if UPS PIco HV3.0 will be reset, will be recovered.**
0x13	fstat	Byte	Mirror	Read	**Read:** Anytime, Return actual **if FAN** is actually running or not (for remote users) When FAN is set to be running (even if not connected physically) the FAN LED is lighting. The intensity of the FAN LED is depending of the FAN Speed (PWM)

0x14	fttemp	Byte	Mirror	R/W	**Integrated Fan Temperature Threshold in Automatic Mode** BCD Fan Running threshold temperature in Celsius, 2 digits i.e. 35, means 35 Celsius. In order to be used (automatic FAN ON/OFF) need to set **fmode** to 0x02. Maximum temperature is 60 Celsius. Higher values will be ignored. FAN will start at 36 Celsius and stop at 35 Celsius. **Read:** Anytime, Return actual **fspeed** value **Write:** 00 – 60 Sets the TO-92 temperature Threshold for the Automatic FAN Start/STop **Default value is set to 35 Celsius**

Example of use – Manual FAN ON/OFF

sudo i2cset -y 1 0x6b 0x13 100 Set the FAN speed to 100

sudo i2cset -y 1 0x6b 0x12 0x01 Set the FAN ON

sudo i2cset -y 1 0x6b 0x12 0x00 Set the FAN OFF

Example of use – Automatic FAN ON/OFF

sudo i2cset -y 1 0x6b 0x13 100 Set the FAN speed to 100

sudo i2cset -y 1 0x6b 0x12 0x02 Set the FAN ON as an Automatic

The default setup is Automatic Mode with 35 Celsius and 50% of FAN speed, so user do not need to change anything if like just to use the FAN. If higher cooling performance is needed (however with more noise) then the **fspeed** should be set to 100 (100%), similar with temperature threshold **fttemp**. However please kindly notice that FAN speed and temperature threshold have been set in order to have best performance with lowest noise.

UPS PIco HV3.0 Battery Type Selection

The **UPS PIco HV3.0** is supporting 3 different chemistry battery types:

- the **LiPO**
- and the **LiFePO4**
- Li-Ion

Both chemistry batteries are available in 2 capacities. Therefore the UPS PIco HV3.0 can be supplied with the following batteries:

- The standard LiPO battery 450 mAh which comes with the UPS PIco HV3.0
- The enhanced LiPO battery with capacity 4000 mAh
- The enhanced LiPO battery with capacity 8000 mAh
- The enhanced LiFePO4 battery with capacity 4000 mAh
- The enhanced LiFePO4 battery with capacity 8000 mAh

Batteries with different chemistry offers different unique features, and needs to be specified on the system setup when changed. The core differences between both chemistry batteries are listed here below. The battery type setting declare the chemistry and not the capacity of the battery. Declaration of the battery chemistry is needed due to different threshold voltages and slightly different charging algorithm. It is mandatory to have declared a proper battery chemistry for a proper system functionality. The default battery chemistry is the LiPO and if not changed it is not needed to change the declaration. Only if the user use the enhanced LiFePO4 batteries it is need to proceed with changed of the battery chemistry declaration.

LiFePO4 Battery	
Nominal voltage	3.2 V
Peak voltage	3.65 V
Absolute Minimum discharge voltage	2.0 V
CV charge voltage [100%]	3.65 V
CV charge voltage [95%]	3.5 V
Charge Temperature	0°-40°C
Discharge Temperature	-10°-60°C

0x6B -> UPS PIco Module Commands

0x07	battype	Byte	Common	R/W	Defines used battery chemistry type: 0x46 – LiFePO4 (ASCII : F) used in version Stack/TopEnd 0x51 – LiFePO4 (ASCII: Q) used in version Plus 0x53 – LiPO (ASCII: S) used in version Stack/TopEnd 0x50 – LiPO (ASCII: P) used in version Plus **Other codes are not allowed**

Example of use

sudo i2cset -y 1 0x6b 0x07 0x46	***LiFePO4 (ASCII : F) used in version Stack/TopEnd***
sudo i2cset -y 1 0x6b 0x07 0x51	***LiFePO4 (ASCII: Q) used in version Plus***
sudo i2cset -y 1 0x6b 0x07 0x53	***LiPO (ASCII: S) used in version Stack/TopEnd***
sudo i2cset -y 1 0x6b 0x07 0x50	***LiPO (ASCII: P) used in version Plus***

Caution: The **UPS PIco HV3.0 HAT** PCB has declared always the default battery chemistry type, and when firmware update is executed the battery chemistry is always changed to PCB defaults, therefore it is needed to re-declare the battery type after firmware update to the used one by the system. Some industrial customers have default declared the LiFePO4 in their systems, but usual the default battery chemistry is LiPO.

UPS PIco HV3.0 HAT Measuring and Monitoring System

The **UPS PIco HV3.0** offer to the user an extended Measuring and Monitoring System that measure and report many system parameters trough installed sensors. Each sensor is reporting the **UPS PIco HV3.0 HAT** status via dedicated variables. In addition there is access to the integrated 12 bits 3 x A/D converters. All monitoring system data are collected in a single entity called **PIco Status** and exists at the I^{2}C address **0x69**. Detailed specifications for each variable (register) as also examples are provided in next pages. The sensors are:

- Powering Mode
- System Variable Changed
- System Error
- Battery Powered Available Running Time (calculated on battery capacity and system current consumption)
- Battery Level
- Raspberry Pi® GPIO 5V Level
- External Powering Level
- Incoming (from Raspberry Pi® GPIO 5V) current

- Outgoing (to Raspberry Pi® GPIO 5V) current
- Incoming (from External Powering) current
- A/D converter 0 Level
- A/D converter 1 Level
- A/D converter 2 Level
- Key pressed (described in the User Applications Hardware Interfaces)
- Embedded NTC temperature (measured on PIco PCB)
- TO-92 Sensor Temperature (measured near to the Raspberry Pi® PCB)
- Opto Coupler
- Integrated Charger Status
- Running PIco validation
- PCB versions
- Bootloader Versions
- Firmware Version

Green marked features has been not activated yet.

Powering Mode

Battery Level

Raspberry Pi® GPIO 5V Level

External Powering Level

UPS PIco HV3.0 12-bit A/D converters

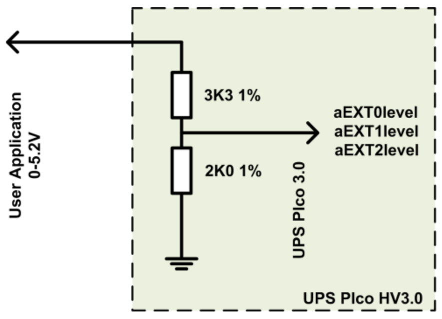
The UPS PIco HV3.0 is equipped with 3 x 12 bits A/D converters. Access to their conversion data is possible via dedicated registers placed at the I^{2}C address 0x69 (0x14, 0x16, 0x18). Those A/D converters read continuously data every 250 uS with conversion time of 3.5 uS per sample. However due to implemented low noise software enhanced filtering in the firmware the effective rate data rate is around of 0.001 sec per reading (each A/D register values is refreshed every 1000us).

Each of the A/D converters is pre-scaled to measure voltage 0-5.2V with implemented on the UPS PIco HV3.0 HAT resistor divider. They are named aEXT0, aEXT1, aEXT2. However, there is also a possibility for the user (if use Terminal Block PCB or additional external resistor) to use two of them as pre scaled of 0-10V, 0-20V, or 0-30V. These two A/D converters are named aEXT1 and aEXT2.

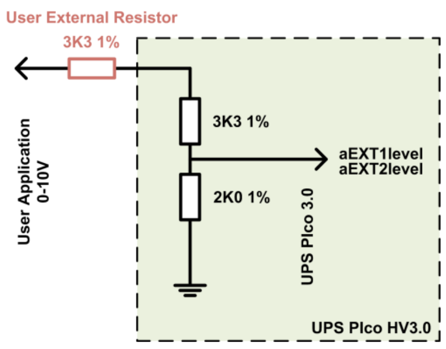
Due to electrical requirements of the integrated A/D converters the impedance is set to low values, therefore some high impedance sensors cannot be read properly as could require higher impedance of A/D converter interface. On such cases it is recommended to use Voltage Follower that converts the sensor high impedance to UPS PIco HV3.0 HAT A/D converters lower one.

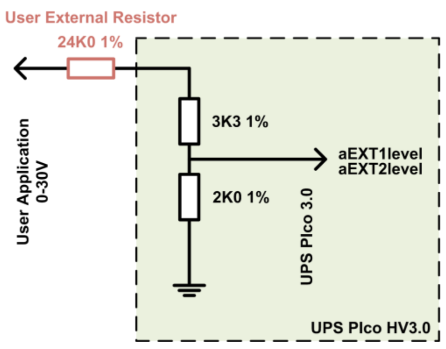
This functionality (of the Voltage Follower) has been implemented on the Terminal Blocks PCB, where on one of the A/D's converters (the aEXT0) a Voltage Follower has been assigned and allows to convert high impedance of any possible used sensor to low impedance on the A/D side. A detailed description of the Terminal Blocks PCB and their functionalities are described in separate section of this manual.

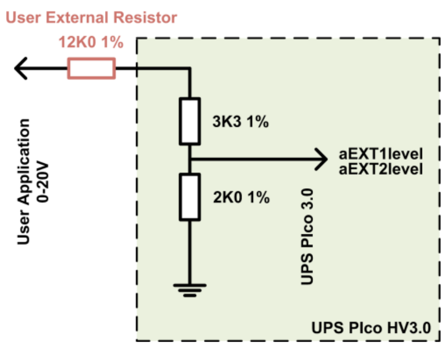
The basic circuit of all A/D converters (the resistor dividers) are shown here below, it is same to all implemented A/D converters in the UPS PIco HV3.0 HAT.



If user decide to use Higher Voltage Interface as pre-scaled of 0-10V, 0-20V, or 0-30V the **Terminal Blocks PCB** should be used, or an **additional resistor** need to be added externally, like in the below pictures. In addition, the register **setA_D (0x08)** at address **0x6b** should be set to a proper value according the below table to keep the proper voltage conversion. If user not like to use embedded voltage converter, then it is needed to disable it via a proper command and read the raw data directly from the related register. All A/D readings have internal reference of 2.048V and are filtered by the firmware with "Olympic Score" and "Low Pass" Filtering.







Caution: The **UPS PIco HV3.0** has implemented an ESD protection on each A/D converter input. This protection protects the system from ESD discharges and **does not** from continuously high voltage applied.

Therefore, it is very important if High Voltage used (10V, 20V or 30V), to be sure that a proper resistor(s) has been used. If smaller resistor(s) that required will be used, then the A/D input will be destroyed permanently, and very possible also the whole UPS PIco HV3.0 HAT PCB

Therefore, user need to take care to be sure that a proper values of resistor(s) has been used.

setA_D Values	AEXT0level Scale	AEXT1level Scale	AEXT2level Scale	AEXT1 Resistor	AEXT2 Resistor
0x00	5.2V	5.2V	5.2V	0K	0K
0x01	5.2V	5.2V	10V	0K	3K3
0x02	5.2V	5.2V	20V	0K	12K0
0x03	5.2V	5.2V	30V	0K	24K0

setA_D Values	AEXT0level Scale	AEXT1level Scale	AEXT2level Scale	AEXT1 Resistor	AEXT2 Resistor
0x00	5.2V	5.2V	5.2V	0K	0K
0x10	5.2V	10V	5.2V	3K3	0K
0x20	5.2V	20V	5.2V	12K0	0K
0x30	5.2V	30V	5.2V	24K0	0K

** Red marked table settings are not unlocked yet in current firmware version*

Any combination of data provided on above table is allowed. The register **setA_D** is 8 bit. The 4th MSB bits are responsible for the **AEXT1level** pre-scale, and the 4th LSB bits are responsible for the **AEXT2level** pre-scale.

On the **UPS PIco HV3.0** PCB the AEXT**0level** is marked as **A50,** the **AEXT1level** is marked as **A15** and the **AEXT2level** is marked as **A30.**

If user need read raw data, then there is a need to write **0xFF** to the **setA_D** register. With raw data option the basic standard resistor divider is used, and the input voltage can not exceed the 5.2V. The maximum reading is 4095 (12 bit A/D). All A/D readings have internal reference of 2.048V and are filtered by the firmware with “Olympic Score” and “Low Pass” Filtering.

Example of use

sudo i2cget -y 1 0x69 0x14 w ***should return value of the aEXT0level***

sudo i2cget -y 1 0x69 0x16 w ***should return value of the aEXT1level***

sudo i2cget -y 1 0x69 0x18 w ***should return value of the aEXT2level***

sudo i2cset -y 1 0x6b 0x08 0x00 ***sets all A/D readings to pre sacled 0-5.2V (default)***

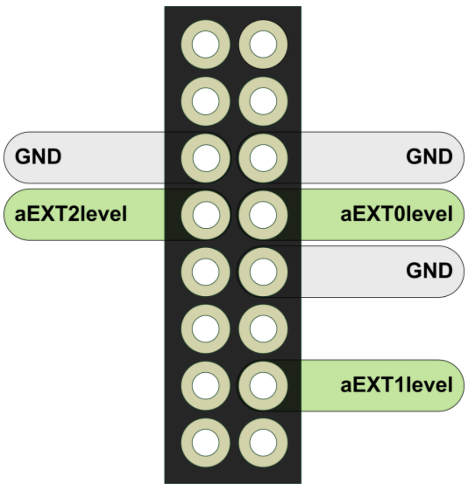
sudo i2cset -y 1 0x6b 0x08 0xff ***sets all A/D readings to raw data (0x0000-0x0fff)***

Registers Located at 0x69 I2C address related to A/D readings

0x14	aEXT0level	Word	Mirror	Read	Means value of the first A/D converter pre scaled to 5.2V. Higher voltage could not be supplied. Readings are in 10th of mV in BCD format
0x16	aEXT1level	Word	Mirror	Read	Means value of the second A/D converter pre scaled to 5.2V. Higher voltage could be supplied with an external resistor divider. Readings are in 10th of mV in BCD format. **If added an extra resistor can be used as pre scaled to 10, 20 or 30V.**
0x18	aEXT2level	Word	Mirror	Read	Means value of the second A/D converter pre scaled to 5.2V. Higher voltage could be supplied with an external resistor divider. Readings are in 10th of mV in BCD format. **If added an extra resistor can be used as pre scaled to 10, 20 or 30V.**

Registers Located at 0x6B I2C address related to A/D settings

0x08	setA_D	Byte	Common	R/W	Defines the pre scaler of the **AEXT1level** and the **AEXT2level** registers. The 4th MSB bits are responsible for the **AEXT1level** pre-scale, and the 4th LSB bits are responsible for the **AEXT2level** pre-scale. **Read:** Anytime, Return actual **setA_D** value **Write:** 0x00 – 5.2V prescale for the **AEXT2level** **Write:** 0x01 – 10V prescale for the **AEXT2level** **Write:** 0x02 – 20V prescale for the **AEXT2level** **Write:** 0x03 – 30V prescale for the **AEXT2level** **Write:** 0x00 – 5.2V prescale for the **AEXT1level** **Write:** 0x10 – 10V prescale for the **AEXT1level** **Write:** 0x20 – 20V prescale for the **AEXT1level** **Write:** 0x30 – 30V prescale for the **AEXT1level** **Write:** 0xFF – all A/D registers will contain raw data **RED Marked** – not implemented yet



Embedded NTC temperature

TO-92 Sensor Temperature

Integrated Charger Status

- PCB versions
- Bootloader Versions
- Firmware Version

UPS PIco HV3.0 System Time Schedulers

The UPS PIco HV3.0 has implemented 2 independent, Time Schedulers. There are:

- The Basic Time Scheduler (**BS**)
- and, The Event Triggered RTC Based System Actions Scheduler (**ETR SAS**)

Both schedulers cannot be used at the same time, and if one of them is selected, the second is deselected and vice versa.

The Register responsible for the Scheduler selection is located in the **0x6b** Registers Set

0x6B -> UPS PIco 0x19 Time Scheduler Selector

This register is used to select the System Time Scheduler. Two values are possible 0x00 (default value) – which means **Basic Scheduler**, or 0x01 – which means **Event Triggered RTC Based System Actions Scheduler**. Setting of it is necessary to select the proper System Time Scheduler.

sudo i2cset -y 1 0x6b 0x19 0x00 to select **BS** (default values)

or

sudo i2cset -y 1 0x6b 0x19 0x01 to select **ETR SAS**

Basic Scheduler

This scheduler is basically used when UPS PIco HV3.0 hardware RTC is not used (therefore not possible to set exact date, time; and synchronize with it) or when user need something ultra-simple, just to make ON/OFF the Raspberry Pi (so no needed to use the complex settings of the ETR SAS). There are only few registered involved in this scheduler and setting up of them is rapid. User need just to set how long Raspberry Pi® should be running, after what time it will be repeated (if so) and how many times it must happen. The time resolution of the **BS** is based on **1 minute**, however everything is adjusted with 1 second accuracy, as each action start/stop is executed at the beginning (first second) of internal RTC counted minute (even if the internal RTC is not set, it is always running). Below picture explain the logic behind of this Basic Scheduler.

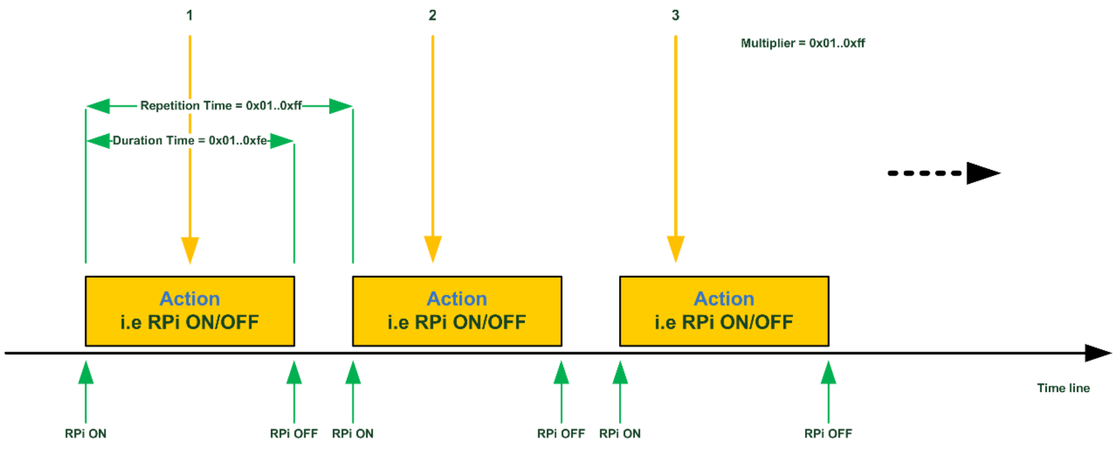


Figure 50 Basic Scheduler

BS Definitions

There are some definitions that need to be specified to have better understanding of the **BS** functionality. There are basically similar to the ETR SAS definitions (described in the next chapter), however are simplified due to adaptation to this simple Basic Scheduler. There are:

BS Action –It is ON/OFF the Raspberry Pi® only

BS Duration Time – Specify time between **BS Action** (ON of the Raspberry Pi®) and their opposite state (OFF of the Raspberry Pi®). In example if Raspberry Pi® **Power ON**, the opposite state is Raspberry Pi® **Power OFF**. Therefore, BS **Duration Time** is time between ON and OFF the Raspberry Pi®.

BS Repetition Time – The **BS Repetition Time** defines the **time** between beginnings of first and the repeated BS Action.

BS Multiplier – Defines how many times **BS Action** will be repeated, up to 254 times or infinitely

Basic Scheduler Involved PICo Registers/Sets

The following PICo Registers are involved in the **Basic Scheduler** programming. There are:

- **BS_duration_time**
- **BS_repetition_time**
- **BS_multipier**

In addition, user need to set properly the **Time Scheduler Selector** and make running the BS by using **BS_ RUN** Register. The **Basic Scheduler** will start at once (start their timers) after the BS_RUN will be set to ON (0x01).

All Registries related to the **Basic Scheduler** are located at the **0x6B -> UPS PIco Module Commands**. There are:

<u>0x6B -> UPS PIco 0x1A BS_duration_time (in minutes)</u>

This register defines how long the ON of Raspberry Pi® (called Action) will be running after starting up. This time must be shorter by at least 1 minute than the repetition time. In Example, if the Raspberry Pi® the repetition time is 11 minutes, the duration time must be maximum 10 minutes (to give 1-minute time for system shutdown). The default value is 0x01. Each value is in minutes. The maximum time is 0xfe (254 minutes). This register can be read when Raspberry Pi® is running, user will see the decreased value as time is passed.

<u>0x6B -> UPS PIco 0x1B BS_repetition_time (in minutes)</u>

This register defines how long after start of the Raspberry Pi® (Action) will be repeated (if so). This time must be longer by at least 1 minute than the duration time of the ON Raspberry Pi® (Action). In Example, if the Raspberry PI will be running for 10 minutes (duration time = 10), the repetition time must be minimum 11 minutes (to give 1-minute time for system shutdown). The default value is 0x02. Each value is in minutes. This register can be read when Raspberry Pi® is running, user will see the decreased value as time is passed.

<u>0x6B -> UPS PIco 0x1C BS_multiplier</u>

This register defines how many times the **Basic Scheduler** Action (Raspberry Pi® ON/OFF) will be running. It can make it run counted times (from 1 up to 254). If programmed 0xff (255) then the Action will be executed unlimited times (repeated continuously). This register can be read when Raspberry Pi® is running, user will see the decreased value as counter is passed.

<u>0x6B -> UPS PIco 0x1D BS_RUN</u>

This register is used to make **Basic Scheduler** running (if all parameters are properly set). By setting the BS_RUN = 0x01 the BS will start running. It is not possible to change any related to BS register value when BS_RUN is active. To do so, you need to deactivate the BS_RUN first.

0x19	Time_Scheduler_Selector	Byte	Common	R/W	Selects which **Scheduler** is used: - 0x00 (default) Basic Scheduler - 0x01 ETR SAS Only one can be selected, and each programming is referred to it.
0x1A	BS_duration_time	Byte	Common	R/W	**Basic Scheduler Action Duration Time** in minutes. Allowed values are 0x01 – 0xfe. Default is 0x01
0x1B	BS_repetition_time	Byte	Common	R/W	**Basic Scheduler Action Repetition Time** in minutes. Allowed values are 0x01 – 0xff. Default is 0x02
0x1C	BS_multipier	Byte	Common	R/W	**Basic Scheduler Action Multiplier**. Allowed values are 0x01 – 0xff. Default is 0x01 Value of 0xff means running (repeating) unlimited times.
0x1D	BS_ RUN	Byte	Common	R/W	Specify when **Basic Scheduler** is running or not. Default is 0x00 (not running). Allowed values are 0x00 and 0x01

Table 12 Basic Scheduler involved Registers

BS Example 1st - Simple Raspberry Pi® ON/OFF executed infinitive times for 1 minutes (ON/OFF every minute)

We need to start up - set ON - the Raspberry Pi®, keep it running for 1 minutes, shutdown it, and after 1-minute start it again. This will be repeated infinitely.

Time_Scheduler_Selector = 0x00;	Select the Basic Scheduler
BS_duration_time = 0x01;	Sets duration time to 1 minute (Raspberry Pi® will run for 1 minute and then shutdown)
BS_repetition_time =0x02;	Sets repetition time to 2 minutes (Raspberry Pi® will started again after 1 minute when shutdown)
BS_multipier = 0xff;	This will be repeated forever
BS_ RUN =0x01;	When user decide, just activate the Basic Scheduler

The data entering should looks like below (it important to follow the below order to avoid any mistake in programming):

1. Make sure to select the **BS** as a current scheduler

   sudo i2cset -y 1 0x6b 0x19 0x00 for making BS as selected scheduler

2. Enter **BS Duration Time**, on our case it is 1 minute

   sudo i2cset -y 1 0x6b 0x1A 0x01 for duration time 1 minute

3. Enter **BS Repetition Time**, on our case it is 2 minutes

   sudo i2cset -y 1 0x6b 0x1B 0x02 for repetition time 2 minutes

4. Enter **BS Multiplier**, on our case it is infinitive

   sudo i2cset -y 1 0x6b 0x1C 0xFF for infinitive running

5. Check if programmed values are OK, by running the below python script

   sudo python status_bs.py

If everything is as expected, run the Basic Scheduler

sudo i2cset -y 1 0x6b 0x1D 0x01

BS Example 2nd- Simple Raspberry Pi® ON/OFF executed 100 times for 1 minutes (ON/OFF every minute)

We need to start up - set ON - the Raspberry Pi®, keep it running for 1 minutes, shutdown it, and after 1-minute start it again. This will be repeated 100 times.

Time_Scheduler_Selector = 0x00;	Select the Basic Scheduler
BS_duration_time = 0x01;	Sets duration time to 1 minute (Raspberry Pi® will run for 1 minute and then shutdown)
BS_repetition_time =0x02;	Sets repetition time to 2 minutes (Raspberry Pi® will started again after 1 minute when shutdown)
BS_multipier = 0x64 (100);	This will be repeated 100 times
BS_ RUN =0x01;	When user decide, just activate the Basic Scheduler

The data entering should looks like below (it important to follow the below order to avoid any mistake in programming):

1. Make sure to select the **BS** as a current scheduler

   sudo i2cset -y 1 0x6b 0x19 0x00 for making BS as selected scheduler

2. Enter **BS Duration Time**, on our case it is 1 minute

   sudo i2cset -y 1 0x6b 0x1A 0x01 for duration time 1 minute

3. Enter **BS Repetition Time**, on our case it is 2 minutes

   sudo i2cset -y 1 0x6b 0x1B 0x02 for repetition time 2 minutes

4. Enter **BS Multiplier**, on our case it is infinitive

   sudo i2cset -y 1 0x6b 0x1C 0x64 for 100 times running

5. Check if programmed values are OK, by running the below python script

   sudo python status_bs.py

If everything is as expected, run the Basic Scheduler

sudo i2cset -y 1 0x6b 0x1D 0x01

Events Triggered RTC Based System Actions Scheduler

The **E**vents **T**riggered **R**TC Based **S**ystem **A**ctions **S**cheduler (**ETR SAS**) is a very advanced functionality that allows user to implement a simple timed Actions (usually ON/OFF) of the Raspberry Pi®, but also a very complicated Actions Schedules depended to External Events and Time without or with involvement of Raspberry Pi®. This functionality can be perfectly combined with **IoT** or any other time dependent applications. The time resolution of the **ETR SAS** is based on **1 minute**, however everything is adjusted with 1 second accuracy, as each action start/stop is executed at the beginning (first second) of internal RTC counted minute. There are implemented 4 parallel working **ETR SAS** running with different Set-up's. That means that i.e. user can set the 1st **ETR SAS** running at night (00:00 – 06:00) every 10 minutes (repeated 20 times), the 2nd **ETR SAS** to run at morning time (06:00 – 10:00) every 30 minutes, and the rest of the day every 1 minute based on 3rd **ETR SAS**. The **ETR SAS** can be based on the **RTC**, but can be also time independent and execute Action triggered by external Event (i.e. A/D). The **Action** can be simple ON/OFF the Raspberry Pi® but also independent of the Raspberry PI® (without switching it ON) just activate the Auxiliary 5V@750mA or Bi-Stable Relay switching. Combination of all **ETR SAS** produce in the result a very complicated state machine able to implement practically any schedule is needed by user.

ETR SAS Definitions

There are some definitions that need to be specified to have better understanding of the **ETR SAS** functionality. There are:

Scheduler – A State Machine that maintains the schedules (states)

Schedules – Set of **Sequences** that contains number of **Actions**, which execution of them is based on **Events** or **RTC**, and are executing by **Scheduler**. In example **Action** is ON/OFF Raspberry Pi® and **Event** is A/D data that fires the **Action** (ON/OFF Raspberry Pi®). **Action** is ON/OFF Raspberry Pi® on requested date and time. **Sequences** contains these **Actions** that can be repeated within one Schedule (i.e. every day) or can happens only once. The definition of Sequence is required to specify the Repetition Time of Sequences.

Sequences – contain one or more **Actions**.

RTC – Real Time Clock (the hardware clock/calendar used/embedded by the **UPS PIco HV3.0A HAT**), synchronized with Raspberry Pi® RTC. It is mandatory to have the PIco RTC synchronized with Raspberry Pi® RTC. It can be easy check with

sudo i2cdetect -y 1

the address **0x68** must be **UU**.

Event – Occurrence that is used for triggering the **Scheduler**. It can be A/D level, IR, 1-wire, RS232, etc.

Action – Result of the **Scheduler** activity. It can be ON/OFF the Raspberry PI®, ON/OFF the Auxiliary 5V@750mA, Set/Reset of the Bi-Stable Relay, 1-wire, RS232 data, etc. The Action does not need to have running the Raspberry Pi®, as it is "above of it" however can contain the Raspberry Pi ® ON/OFF procedure.

Action Duration Time – Specify time between **Action** and their opposite state. In example if **Action** is Raspberry Pi® **Power ON**, the opposite state is Raspberry Pi® **Power OFF**. Therefore, **Duration** is time between ON and OFF the Raspberry Pi®. In case of use i.e. bi-Stable Relay the **Duration** is time between **Set** and **Reset**. In case of use i.e. programmable **5V@750mA** the **Duration** is time between 5V@750mA **ON** and **OFF**. There is no need to have Raspberry Pi® running at the same time, however it could be. These two **Actions** are independent.

Action Repetition Time – Each **Action** can be repeated within the same **Schedule**. The **Action Repetition** defines the **time** between beginnings of first and the repeated Action. In example Action will be defined to be executed at 10:00. The **Action Repetition Time** will define Repetition of the same action after XX min (Repetition time) i.e. 30 minutes. Therefore, if **Action** is switch Raspberry Pi® at 10:00 for **Action Duration** of 10 minutes, the **Action Repetition Time** will be, to switch it again after 30 minutes. Thus, could be repeated **Action Multiplier** times if needed. The Action Repetition Time could be 0.

Action Multiplier – Defines how many times **Action** will be repeated within the same Sequence.

Sequence Repetition Time – One **Schedule** contains multiple **Sequences**. That could be or not repeated. Each **Sequence** contains one or more **Actions**. The Sequence Repetition Time defines the repletion of the Sequence. In example every day, every week, etc.

The below picture shows 2 Schedules that are executed by Scheduler. One of the Schedules contain Sequence with multiple Actions (3) repeated every day. The second one contains Schedule with single action (Relay ON/OFF) that is repeated every day (in different time). Both are running independently. This will help you for better understanding of each definition.

ETR SAS Definitions Dependencies

The **UPS PIco HV3.0** execute (or not if not activated) the **ETR SAS Scheduler**. The **Scheduler** contains up to 4 **Schedules** that are executed separately when the **Scheduler** is running. User can activate from 1 to 4 **Schedules**. Each Schedule have their own **Sequence**. The **Sequence** can be repeated or not within their **Schedule**. Each **Sequence** hold a number (at least 1) of **Actions**. Each **Action** can be repeated within the same **Sequence** counted times. Actions can be triggered by **RTC** or **Events.**

Raspberry Pi® ETR SAS Self Programming

It is possible that invoked by ETR SAS (switched ON) Raspberry Pi® after achieving of their external events goals will re-program parameters (Schedules) of their ETR SAS with different parameters, or stop execution of it. Thus, make practically unlimited options of running of ETR SAS.

Template for ETR SAS preparation

To simplify preparation of user born ETR SAS, there is provided a template where user can easy enter (draw) their own schedule, and the simple   program PICo SAS registers based on that. To use it, it is needed to print the page with it (it is also provided in a separate PDF).

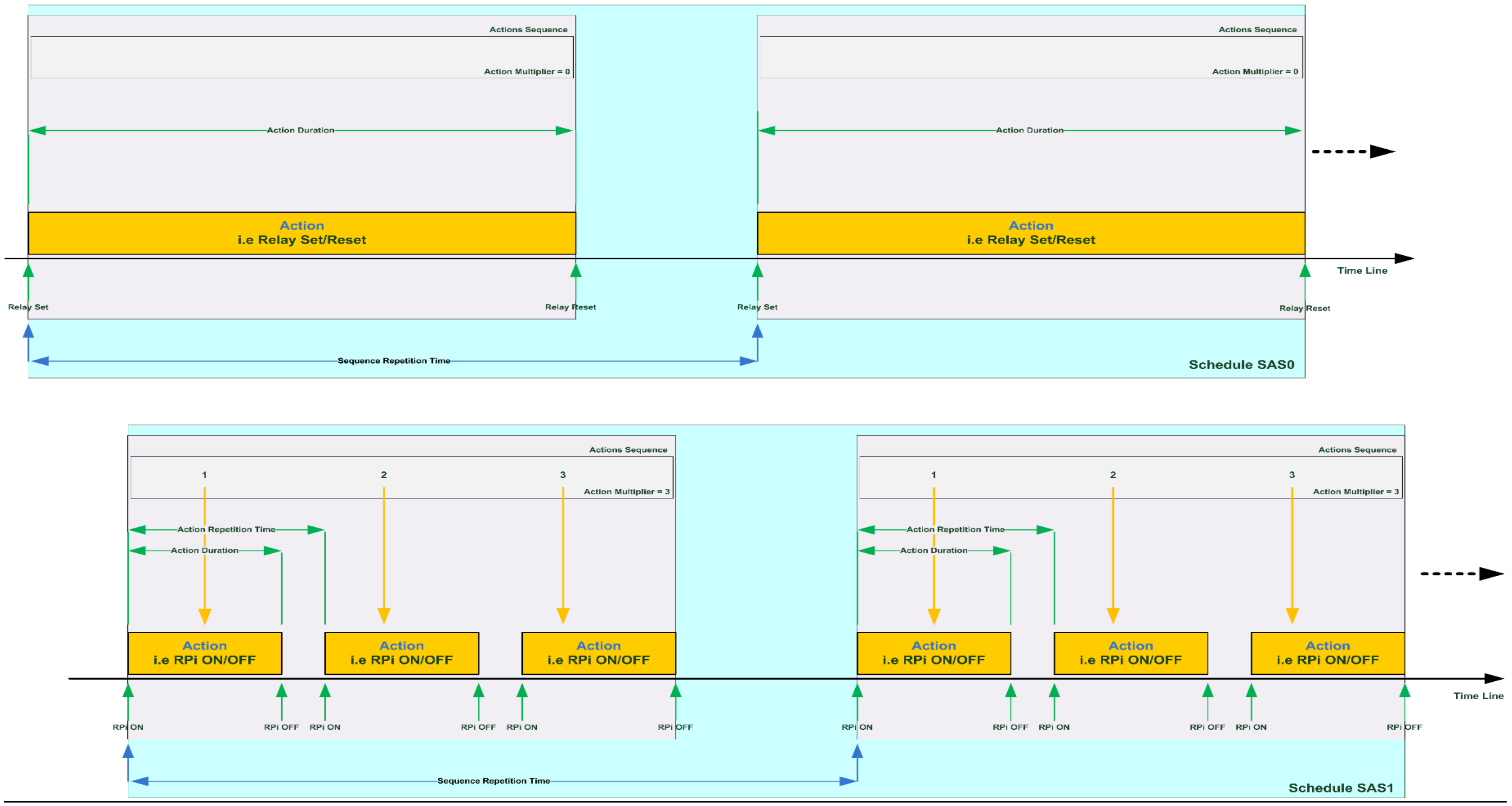


Figure 51 Graphical Presentation of ETR SAS definitions

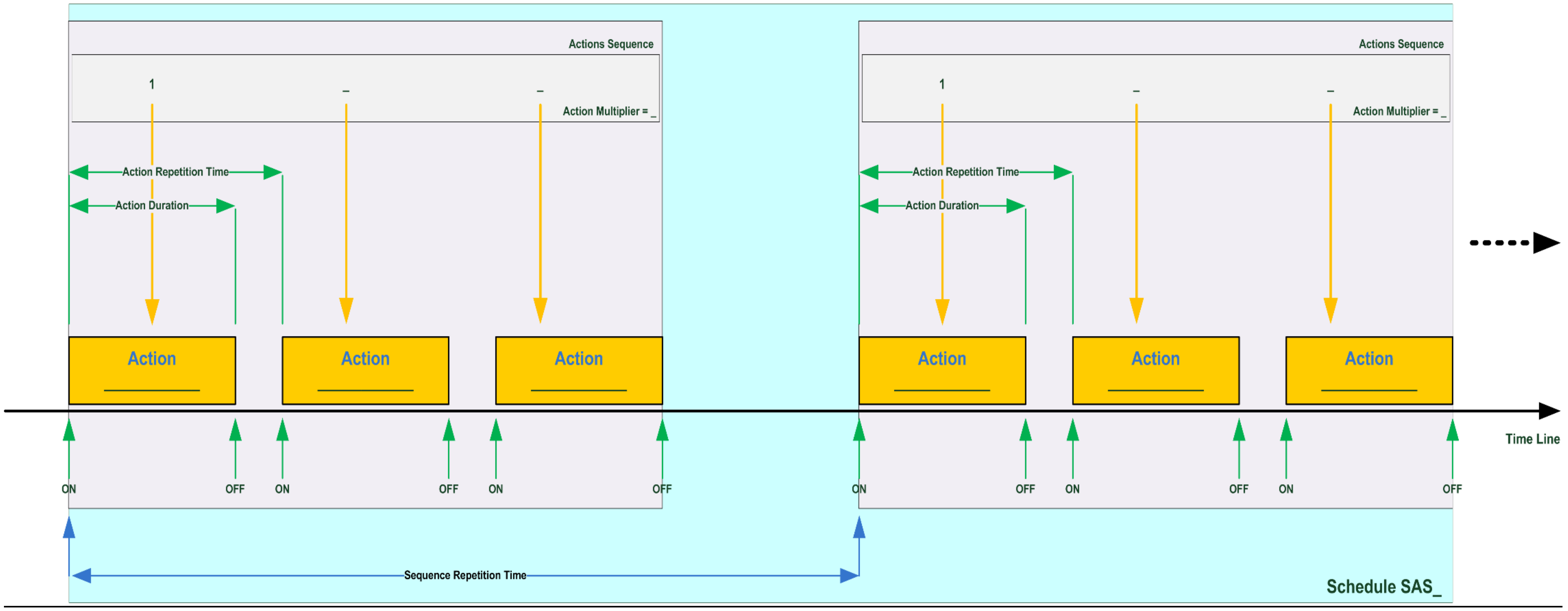


Figure 52 Template for ETR SAS user preparation

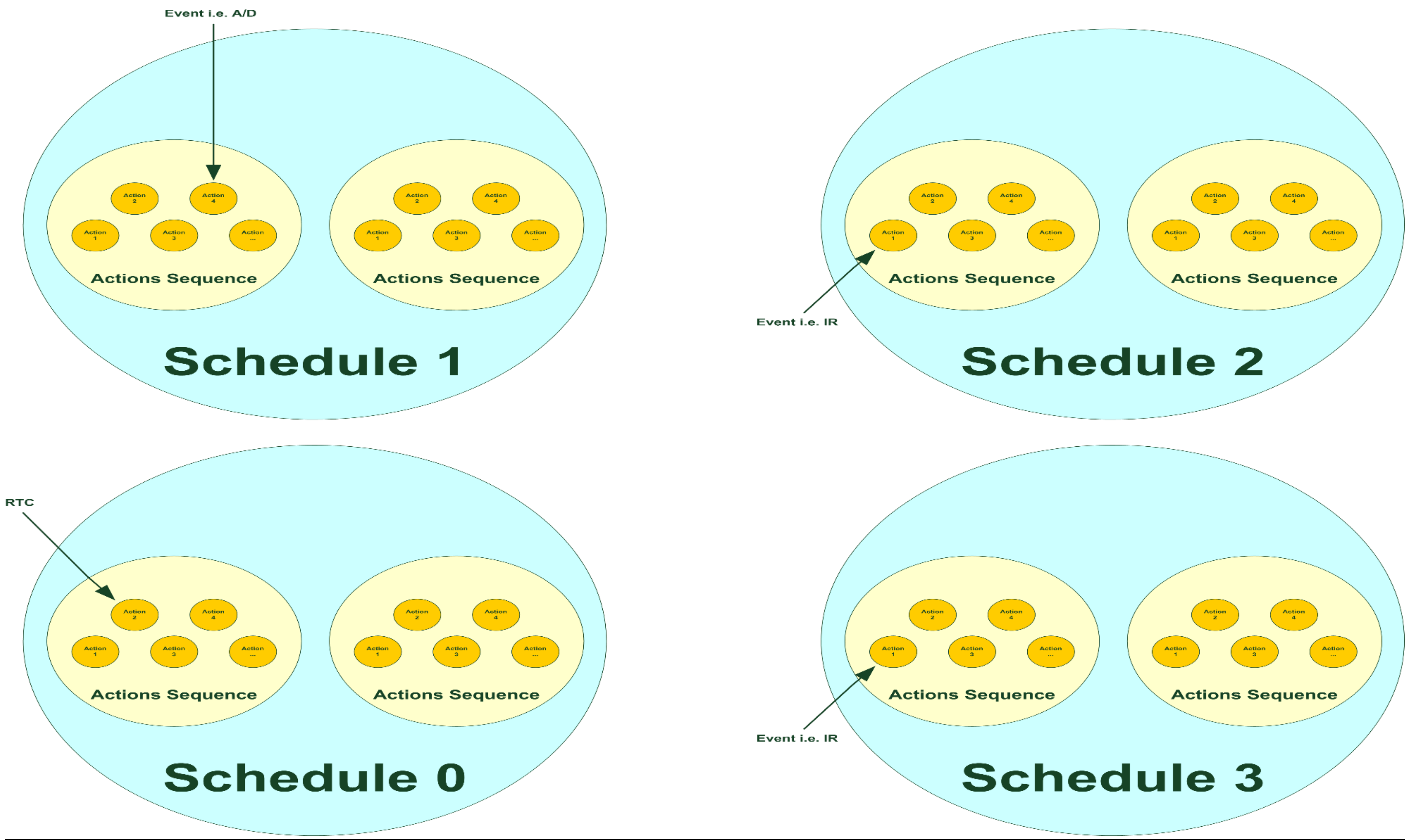


Figure 53 ETR SAS Definitions Dependencies

ETR SAS Involved PICo Registers/Sets

The following PICo Registers are involved in the **ETR SAS** Schedules programming.

0x6A -> UPS PIco Hardware RTC Registers Direct Access

This set of registers has mirror image of the Hardware UPS PIco HV3.0 RTC (each value separately). They can be read at any time. However, cannot be written as it will be overwritten by UPS PIco HV3.0 firmware. They can be used for reference of the HW RTC for various application.

0x6B -> UPS PIco 0x16 SAS Selection Register

This register is used to select the current SAS (from 0 – 3) for programming purposes. As far the **ETR SAS** is programming (set-up) user can write values to it selecting the active **ETR SAS** for programming or reading related values. After ETR SAS activation, values will be overwritten with current ETR SAS execution.

0x6B -> UPS PIco 0x17 SAS RUN Register

This register is used to make **ETR SAS** running (all activated Schedules). By setting the SAS RUN all activated SAS Scheduled Actions will be executed in their time frame. It is not possible to change any related to ETR SAS register value when SAS RUN is active. To do so, you need to deactivate the SAS RUN first.

0x6B -> UPS PIco 0x18 Next_Action_Rtime Register

This register is used to give information to the user about remining time for the next ongoing event (for any Schedule and any Sequence – just next one). This information is given when remining time to the next Action is smaller than 24 hours (1439 minutes)

0x6B -> UPS PIco 0x19 Time Scheduler Selector

This register is used to select the System Time Scheduler. Two values are possible 0x00 (default value) – which means **Basic Scheduler**, or 0x01 – which means **Event Triggered RTC Based System Actions Scheduler**. Setting of it is necessary to select the proper System Time Scheduler.

0x6c -> ETR SAS Start Time Stamp Registers

This set of registers holds all required values to set up the Start Time of the Action(s)

0x6d -> ETR SAS Actions Running Time Stamp

This set of registers holds all required values to set up the Action Running Time Stamp, Repetitions, Multiplier, etc.

0x6e -> ETR SAS Actions Stamp

This set of registers holds all defined Actions that can be used (i.e. Raspberry Pi® ON/OFF, Bi-Stable Relay ON/OFF etc.)

0x6f -> ETR SAS Events Stamp

This set of registers contains all defined Events that can be used for Actions Triggering

ETR SAS Working Examples

Please check below settings to understand exactly and properly the meanings and the **ETR SAS** functionality. Below examples with their settings up should be used as leads for user dedicated Schedules settings.

Definition of the 1st Example - Simple Raspberry Pi® ON/OFF Schedule executed 1 time for 1 minutes and repeated every day

We need to start up - set ON - the Raspberry Pi® at 10:00 (date for the first-time start-up is 20th August 2017). The Raspberry Pi® will run for 1 minute (executing their tasks), then system will shut down. Next day the above Sequence (has only one Action) will be repeated. Please check below settings to understand exactly and properly the meaning of the **ETR SAS** vocabulary. Involved Registers and programmed values for this example are the following:

0x6A -> UPS PIco Hardware RTC Registers Direct Access

Not needed. Can be used just for monitoring or any other application.

0x6B -> UPS PIco 0x16 SAS Selection Register

SAS_number = 0x00;	means it will use for that Schedule the SAS0

0x6B -> UPS PIco 0x17 SAS RUN Register

SAS_RUN = 0x00;	during programming phase and then must be set to 0x01 to make ETR SAS running

0x6B -> UPS PIco 0x19 Time Scheduler Selector

Time_Scheduler_Selector = 0x01;	This register is used to select the System Time Scheduler. Two values are possible 0x00 (default value) – which means **Basic Scheduler**, or 0x01 – which means **Event Triggered RTC Based System Actions Scheduler**. Setting of it is necessary to select the proper System Time Scheduler.

0x6c -> ETR SAS Start Time Stamp Registers

Active = 0x01;	means that this Sequence is active when Scheduler will be activated (so will be executed). Sequence contains one or more Actions.
Year = 0x17;	means it will start at Year 2017
Month = 0x08;	means it will start at August
Mday = 0x20;	means it will start at 20th of declared above month (August)
Hour = 0x10;	means it will start at 10 morning time
Minute = 0x00;	means it will start exactly at 10:00

0x6d -> ETR SAS Actions Running Time Stamp

Action Duration = 0001;	means it will run for 1 minute

Action Repetition Time = 00;	means it will be not repeated within the same sequence (any value is allowed if Action Multiplier = 0x01)
Action Multiplier = 01;	means it will happen 1 time within the same Sequence
Sequence Repetition Time = 24;	means this (above described) sequence will be repeated every day (every 24 hours).

0x6e -> ETR SAS Actions Stamp

Action RPi_PON = 0x01;	means that Action of this Scheduler will be **Raspberry Pi® ON** and (after Action Duration Time - in our example 1 minute) **OFF**

0x6f -> ETR SAS Events Stamp

Not involved. Keep all values 0x00. Does not matter whatever is entered.

Definition of the 2nd Example - Simple Bi-Stable Relay ON/OFF Schedule executed 1 time for 3 minutes and repeated every day.

We need to start up - set ON - the Bi-stable Relay at 09:59 (date for the first-time start-up is 20th August 2017). The Bi-stable Relay will run for 3 minutes starting up one minute before the Raspberry Pi® on Example 1st (executing their tasks), then 1 minute after will be OFF. Next day the above Sequence (that has only one Action) will be repeated. If both Schedules will be activated then i.e. powering can be supplied to external device, Raspberry Pi® then will be activated and when task is finished, Raspberry Pi and then (after one minute) the external device will be deactivated.

Please check below settings to understand exactly and properly the meaning of the **ETR SAS** vocabulary. Involved Registers and programmed values for this example are the following:

0x6A -> UPS PIco Hardware RTC Registers Direct Access

Not needed. Can be used just for monitoring or any other application.

0x6B -> UPS PIco 0x16 SAS Selection Register

SAS_number = 0x01;	means it will use for that Schedule the SAS1

0x6B -> UPS PIco 0x17 SAS RUN Register

SAS_RUN = 0x00;	during programming phase and then must be set to 0x01 to make **ETR SAS** running

0x6B -> UPS PIco 0x19 Time Scheduler Selector

Time_Scheduler_Selector = 0x01;	This register is used to select the System Time Scheduler. Two values are possible 0x00 (default value) – which means **Basic Scheduler**, or 0x01 – which means **Event Triggered RTC Based System Actions Scheduler**. Setting of it is necessary to select the proper System Time Scheduler.

0x6c -> ETR SAS Start Time Stamp Registers

Active = 0x01;	means that this Sequence is active when Scheduler will be activated (so will be executed). Sequence contains one or more Actions.
Year = 0x17;	means it will start at Year 2017
Month = 0x08;	means it will start at August
Mday = 0x20;	means it will start at 20th of declared above month (August)

Hour = 0x09;	means it will start at 09-hour morning time
Minute = 0x59;	means it will start exactly at 09:59

0x6d -> ETR SAS Actions Running Time Stamp

Action Duration = 0003;	means it will run for 3 minutes (2 minutes longer than Raspberry Pi® in the 1st Example)
Action Repetition Time = 00;	means it will be not repeated within the same sequence (any value is allowed if Action Multiplier = 0x01)
Action Multiplier = 01;	means it will happen 1 time within the same Sequence
Sequence Repetition Time = 24;	means this (above described) sequence (that hold one action) will be repeated every day (every 24 hours).

0x6e -> ETR SAS Actions Stamp

Action BR_Set = 0x01;	means that Action of this Scheduler will be **Bi-Stable Relay Set** and (after Action Duration Time) **Reset**

0x6f -> ETR SAS Events Stamp

Not involved. Keep all values 0x00.

Definition of the 3rd Example - Simple Raspberry Pi® ON/OFF Schedule executed 60 times for 1 minute every 2 minutes and repeated every day

We need to start up - set ON - the Raspberry Pi® at 10:00 (date for the first start-up is 20th August 2017). The Raspberry Pi® will run for 1 minutes (executing their tasks – i.e. making photos), then system will shut down. This will be repeated every 2 minutes for 60 times (totally for 2 hours – 120 minutes). Next day the above Sequence (having 60 Actions) will be repeated. Please check below settings to understand exactly and properly the meaning of the **ETR SAS** vocabulary. Involved Registers and programmed values for this example are the following:

0x6A -> UPS PIco Hardware RTC Registers Direct Access

Not needed. Can be used just for monitoring or any other application.

0x6B -> UPS PIco 0x16 SAS Selection Register

SAS_number = 0x00;	means it will use for that Schedule the SAS0 (not use this with above examples)

0x6B -> UPS PIco 0x17 SAS RUN Register

SAS_RUN = 0x00;	during programming phase and then must be set to 0x01 to make **ETR SAS** running

0x6B -> UPS PIco 0x19 Time Scheduler Selector

Time_Scheduler_Selector = 0x01;	This register is used to select the System Time Scheduler. Two values are possible 0x00 (default value) – which means **Basic Scheduler**, or 0x01 – which means **Event Triggered RTC Based System Actions Scheduler**. Setting of it is necessary to select the proper System Time Scheduler

0x6c -> ETR SAS Start Time Stamp Registers

Active = 0x01;	means that this Sequence is active when Scheduler will be activated (so will be executed). Sequence contains one or more Actions.
Year = 0x17;	means it will start at Year 2017
Month = 0x08;	means it will start at August
Mday = 0x20;	means it will start at 20th of declared above month (August)
Hour = 0x10;	means it will start at 10 morning time
Minute = 0x00;	means it will start exactly at 10:00

0x6d -> ETR SAS Actions Running Time Stamp

Action Duration = 0001;	means it will run for 1 minute
Action Repetition Time = 02;	means it will be repeated after 2 minutes from starting time of the earlier one
Action Multiplier = 60;	means it will happen 60 times within the same Sequence
Sequence Repetition Time = 24;	means this (above described) sequence will be repeated every day (every 24 hours).

0x6e -> ETR SAS Actions Stamp

Action RPi_PON = 0x01;	means that Action of this Scheduler will be **Raspberry Pi® ON** and (after Action Duration Time) **OFF**

0x6f -> ETR SAS Events Stamp

Not involved. Keep all values 0x00.

Setting-up the ETR SAS

To set-up the **ETR SAS** user need to continue with some simple steps. Current firmware implementation requires I^{2}C interface, however to simplify the settings-up, a monitoring of settings is implemented also via serial port. It is not necessary to use this monitoring tool, however it is very usefully, as each setting up step is confirmed by messages send to the Serial Terminal. It is also possible to use a simple python script that is printing out on the SSH the status read from the I^{2}C (and then the Serial Port Terminal – i.e. minicom – is not needed).

If user like to use this Serial Port Monitoring option, then need to activate the Serial Port on the **UPS PIco HV3.0A HAT**, and make available the serial port on the Raspberry Pi®, as also start second SSH session where the minicom will be running. To do that please follow below steps:

Make sure that the serial port in Raspberry Pi® is free for user application. This task has been described in very details in the chapter related to the firmware update.

Make sure that i.e. minicom is installed

sudo apt-get install minicom

Activate the Serial Port in the **UPS PIco HV3.0A HAT** i.e. to **38400** bps

sudo i2cset -y 1 0x6b 0x02 0x04

Start second SSH session or terminal and on the second SSH run the minicom

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

With or without monitoring, user can start the setting-up of the **ETR SAS**. To set-up it is needed to program **ETR SAS** registers for depending application need to be time scheduled.

There are 4, independent timed, **ETR SASs** called **Schedules** running at the same time. Only these ones that has been activated will be executed (so if user activate the SAS0 - will be executed the SAS0 only, if user activate the SAS0 and SAS1 – will be executed SAS0 and SAS1, etc.). They need to be setup to have a working system (only those are used). After programming user need to set the **Scheduler** running (by setting ON the 0x6B -> UPS PIco 0x17 SAS RUN Register), and have **Schedules** to be executed. Therefore, if one or more ETR SAS is not used, then need to be deactivated and not need to be set-up. The setup procedure is executed for the selected **ETR SAS**, so to setup it; need to be selected one, and this one that will be programmed (set-up). There is no need to program all **ETR SAS**, just these ones that will be running (used). If one or more ETR SAS selected to be used, user need to set its number on the selection register placed on the **0x6b** address and location **0x16**, each one when programming it.

0x16	SAS_number	Byte	Common	R/W	Define the current ETR SAS that is programmed or read. Default is 0. Allowed number are 0,1,2,3.
0x17	SAS_RUN	Byte	Common	R/W	Specify when **Scheduler** is running or not. Default is 0x00 (not running). Allowed values are 0x00 and 0x01
0x18	Next_Action_Rtime	Word	Mirror	R/W	Specify the minutes of the next Action in minutes if it is less than 24 hours to their execution (1439 minutes or less)
0x19	Time_Scheduler_Selector	Byte	Common	R/W	Selects which **Scheduler** is used: - 0x00 (default) Basic Scheduler - 0x01 ETR SAS Only one can be selected, and each programming is referred to it.

Table 13 ETR SAS Registers in the 0x6B set

First, user need to make selected the ETR SAS by writing to the **Time_Scheduler_Selector** register. Two values are possible 0x00 (default value) – which means **Basic Scheduler**, or 0x01 – which means **Event Triggered RTC Based System Actions Scheduler**. Setting of it is necessary to select the proper System Time Scheduler. For the case of the ETR SAS (current examples), the following should be done

sudo i2cset -y 1 0x6b 0x19 0x01 to select **ETR SAS**

Before user start programming or reading anything need to select the **SAS_number** by writing to it required number (i.e. 0x00) that all steps are referring to it.

sudo i2cset -y 1 0x6b 0x16 0x00

The 0x00 is the default value set by the **UPS PIco HV3.0A HAT** firmware. Each below programming steps will be addressed to this one selected with above command.

This follows all programing steps as described below. All of them are specified to selected **SAS_number**.

Here below are presented step by step programming each of examples defined above.

Setting-up them user should know that each entry is basically protected from wrong data entering. If user write a wrong data system will inform about it, with multiple blinking of User LEDs (all three) and long beep, alternatively if data are accepted it will just blink once and short beep. In addition, messages are send over the PIco Serial Port to the Raspberry Pi®. However, system is not protected from any kind of user mistakes, therefore it is usefully to use the given empty paper printed template (in PDF format) to have a better view of your current under preparation Schedule.

Setting Up of the 1st Example - Simple Raspberry Pi® ON/OFF Schedule executed 1 time for 1 minute and repeated every day

<u>0x6A -> UPS PIco Hardware RTC Registers Direct Access</u>

Setting up of these Registers is not possible. There are used only for monitoring.

<u>0x6B -> UPS PIco 0x16 SAS Selection Register</u>

Before start setting-up of ETR SAS user need to select the current Scheduler. In case of the 1st Example it is number 0;

```
sudo i2cset -y 1 0x6b 0x16 0x00
```

<u>0x6c -> ETR SAS Start Time Stamp Registers</u>

Setting up of the ETR SAS **Start Time Stamp** require to program the following registers, as described in detail here below:

Address	Name	Size	Type	R/W	Explanation
0x00	active	Byte	Common	R/W	Activation Stamp 0x00 not active (Stop), 0xff active (Start) of current SAS (Scheduler)
0x01	minute	Byte	Common	R/W	Starting Minute of hour in BCD - 2 digits (0-59) i.e. 22
0x02	hour	Byte	Common	R/W	Starting Hour of the Day in BCD - 2 digits (0-23) i.e. 22
0x03	mday	Byte	Common	R/W	Starting Day of the Month in BCD - 2 digits (1-31) i.e. 22
0x04	month	Byte	Common	R/W	Starting Month in BCD - 2 digits (1-12) i.e. 12
0x05	year	Byte	Common	R/W	Starting Year in BCD - 2 digits (0-99) i.e. 16

Table 14 ETR SAS Start Time Stamp Registers

According to specification of the 1st Example need to set below values:

Active = 0x01;	means that this Sequence is active when Scheduler will be activated (so will be executed when scheduler is running). Sequence have one or more Actions.
Year = 0x17;	means it will start at Year 2017
Month = 0x08;	means it will start at August
Mday = 0x20;	means it will start at 20th of declared above month (August)
Hour = 0x10;	means it will start at 10 hours morning time
Minute = 0x00;	means it will start exactly at 10:00

The data entering should looks like below (it important to follow the below order to avoid any mistake in programming):

6. Activate the current (already selected ETR SAS) by entering 0xff or (0x01) to the proper register

sudo i2cset -y 1 0x6c 0x00 0x01 for making the Schedule (ETR SAS) Active

7. Enter **Year** for start, year must be the same with actual or higher, and **not** the past. Two digits only in BCD format i.e. 2017 should be 0x17. Possible to program up to 2099.

   sudo i2cset -y 1 0x6c 0x05 0x17 for starting year (in BCD)

8. Enter **Month** for start, month must be the same with actual or higher, and **not** the past. Two digits in BCD format i.e. August should be 0x08. Allowed from 0x01 up to 0x12.

   sudo i2cset -y 1 0x6c 0x04 0x08 for starting month (in BCD)

9. Enter **Month Date** for start, month day must be the same with actual or higher, and **not** the past. Two digits in BCD format i.e. 10th should be 0x10 Allowed from 0x01 up to 0x31. Current version of firmware recognizes the leap year (so February as 28/29), as also end of months as 30/31 so user not need to take extra care to avoid such mistakes. Just when entering the improper Month Date, wrong data will be not accepted.

   sudo i2cset -y 1 0x6c 0x03 0x20 for starting month date (in BCD)

10. Enter **Hour** for start, hour must be the same with actual or higher, and **not** the past. Two digits in BCD format i.e. 20:00 should be 0x20. Allowed from 0x00 up to 0x23, and always in 24h format.

    sudo i2cset -y 1 0x6c 0x02 0x10 for starting hour (in BCD)

11. Enter **Minute** for start, minute must be the same with actual or higher, and **not** the past. Two digits in BCD format i.e. 45th should be 0x45. Allowed from 0x00 up to 0x59.

    sudo i2cset -y 1 0x6c 0x01 0x00 for starting minute (in BCD)

12. A simple python script can be used. This script can be executed at any time during programming of any registered of ETR SAS.

    sudo python status_etrsas.py

Below steps enters Duration of Running and Repetition time.

0x6d -> ETR SAS Actions Running Time Stamp

The second **ETR SAS** registers set is the **Running Time Stamp**, located at **0x6d**. It contains set of 4 registers, that specify detailed time **Action Duration** should run, as also the **ETR SAS Action Repetition Time, Action Multiplayer** and **Sequence Repetition Time** Register. Setting-up them user should know that each entry is protected from wrong data. If user write a wrong data system will inform about it, with multiple blinking of User LEDs (all three) and long beep, alternatively if data are accepted it will just blink once and short beep. In addition, messages are send over the PIco Serial Port to the Raspberry Pi® like in previous settings. By default, all **Repetitions** are set to default values as specified in below table.

Address	**Name**	**Size**	**Type**	**R/W**	**Explanation**
0x00	Action_Duration	Word	Common	R/W	In minutes. From 1-1439 minutes (23hours and 59 minutes), default value is 0x0001 (Action Duration of 1 minute) Higher numbers than 1439 (decimal) will be ignored 0xffff in hex means a special action (not implemented yet)
0x02	Action_Repetition_Time	Byte	Common	R/W	Define Repeated Time of the same Action in minutes. Measures time from beginning of Previous Action to the beginning of the next one. Time from 1 to 255 every XX minutes: 00 – not repeated (only once for Duration time, on programed time) i.e. 0x0010 means every 10 minutes (from one Action beginning to next Action beginning) Default value is 00 (no repetition)
0x03	Action_Multiplier	byte	Common	R/W	Defines how many times the Action will be repeated within the same Sequence (0 – 255) Default value is 0, Action not repeated Causion: If One of the registeres **0x02** and **0x03** is 0, action is not repeated.
0x04	Sequence_Repetition_Time	byte	Common	R/W	Define Repeated Time of the Saquence in hours. Measures time from beginning of Previous Sequence to the beginning of the next one. within the same Schedule. 1 – every hour 2 – every 2 hours ..... 24 – every 24 hours The total time of repeated Actions must be lower that repetition time. System check it automaticly and wrong values are rejected. A message and LED blinking oocurs. Default value is 24, Sequence will be repeated next day The total time of (**Action_Duration** + **Action_Repetition_Time**) * **Action_Multiplier** must be smaller of the **Sequence_Repetition_Time**

Table 15 ETR SAS Actions Running Time Stamp

According to specification of the 1st Example need to set below values:

Action Duration = 0x0001;	means it will run for 1 minute
Action Repetition Time = 0x02;	means it will be repeated after 2 minutes from starting time
Action Multiplier = 0x060;	means it will happen 60 times within the same Sequence
Sequence Repetition Time = 0x24;	means this (above described) sequence will be repeated every day (every 24 hours).

The data entering should looks like below (it important to follow the below order to avoid any mistake in programming):

1. Enter **Action_Duration** to specify how long system must running from 1-1439 minutes.

   ***sudo i2cset -y 1 0x6d 0x00 0001* w** running for 1 minutes

2. Enter **Action_Repetition_Time** to define the Repeated Time of the same Action in minutes. Measuring time from beginning of Previous Action to the beginning of the next one

   sudo i2cset -y 1 0x6d 0x02 02 repeated every 2 minutes

3. Enter **Action_Multiplier** to define how many times the **Action** will be repeated within the same **Sequence**

   sudo i2cset -y 1 0x6d 0x03 60 repeated 60 times

4. Enter **Sequence_Repetition_Time** to define Repeated Time of the Saquence

   sudo i2cset -y 1 0x6d 0x04 24 repeated every 24 hours

0x6e -> ETR SAS Actions Stamp

The third **ETR SAS** registers set is the **Actions Stamp**, located at **0x6e**. Current firmware implementation contains set of 3 registers, that specify **Action Stamps** should be activated if used. The same **Actions** can be assigned to various Schedules, as also the same Schedule can have (activate) more than one **Action**. User need to carefully check the activated actions before use them. It is very usefully and strongly recommended to draw on a paper the scenario planned to be used, helpfully for doing that is the **Template for ETR SAS user preparation.**

Address	**Name**	**Size**	**Type**	**R/W**	**Explanation**
0x00	RPi_PON	Byte	Common	R/W	Raspberry Pi Power ON Activate: 0x01 Deactivate: 0x00 Default: 0x00 Write 0x01 to have this Action Active and switch Raspberry Pi® Powering ON
0x01	5V_PON	Byte	Common	R/W	Auxiliary 5V@750mA and 3V3 Power ON Activate: 0x01 Deactivate: 0x00 Default: 0x00 Write 0x01 to have this Action Active and switch Auxiliary 5V@750mA and 3V3 Powering ON

0x02	BR_Set	Byte	Common	R/W	Bi-Stable Relay Set Activate: 0x01 Deactivate: 0x00 Default: 0x00 Write 0x01 to have this Action Active and Set the Bi-Stable Relay

Table 16 ETR SAS Actions Stamp

Acording to specification of the 1st Example need to set below values:

Action RPi_PON = 0x01;	means that Action of this Scheduler will be **Raspberry Pi® ON** and (after Action Duration Time) **OFF**

The data entering should looks like below (it important to follow the below order to avoid any mistake in programming):

1. Enter **Action RPi_PON** to specify what action need to be executed

sudo i2cset -y 1 0x6e 0x00 01 for RPi_PON = 0x01

<u>0x6f -> ETR SAS Events Stamp</u>

Not involved, as also not implemented in this version of firmware.

Setting Up of the 2nd Example - Simple Bi-Stable Relay ON/OFF Schedule executed 1 time for 15 minutes and repeated every day.

0x6A -> UPS PIco Hardware RTC Registers Direct Access

Setting up of these Registers is not possible. There are used only for monitoring.

0x6B -> UPS PIco 0x16 SAS Selection Register

Before start setting-up of ETR SAS user need to select the current Scheduler. In case of the 2nd Example it is number 1;

sudo i2cset -y 1 0x6b 0x16 0x01

0x6c -> ETR SAS Start Time Stamp Registers

Setting up of the **ETR SAS Start Time Stamp** need to program their registers, as described in detail here below. Acording to specification of the 1st Example need to set below values:

Active = 0x01;	means that this Sequence is active when Scheduler will be activated (so will be executed). Sequence conatin one or more Actions.
Year = 0x17;	means it will start at Year 2017
Month = 0x08;	means it will start at August
Mday = 0x20;	means it will start at 20th of delclared above month (August)
Hour = 0x09;	means it will start at 09 morning time
Minute = 0x59;	means it will start exactly at 09:59

The data entering should looks like below (it important to follow the below order to avoid any mistake in programming):

1. Activate the current (already selected ETR SAS) by entering 0xff or (0x01) to the proper register

   sudo i2cset -y 1 0x6c 0x00 0x01 for making the Schedule (ETR SAS) Active

2. Enter **Year** for start, year must be the same with actual or higher, and not the past. Two digits only in BCD format i.e. 2017 should be 0x17. Possible to program up to 2099.

   sudo i2cset -y 1 0x6c 0x05 0x17 for starting year (in BCD)

3. Enter **Month** for start, month must be the same with actual or higher, and not the past. Two digits in BCD format i.e. August should be 0x08. Allowed from 0x01 up to 0x12.

   sudo i2cset -y 1 0x6c 0x04 0x08 for starting month (in BCD)

4. Enter **Month Date** for start, month day must be the same with actual or higher, and not the past. Two digits in BCD format i.e. 10th should be 0x10 Allowed from 0x01 up to 0x31. Current version of firmware recognizes the leap year (so February as 28/29), as also end of months as 30/31 so user not need to take extra care to avoid such mistakes. Just when entering the unproper Month Date, wrong data will be not acceted.

   sudo i2cset -y 1 0x6c 0x03 0x20 for starting month date (in BCD)

5. Enter **Hour** for start, hour must be the same with actual or higher, and not the past. Two digits in BCD format i.e. 20:00 should be 0x20. Allowed from 0x00 up to 0x23, and always in 24h format.

   sudo i2cset -y 1 0x6c 0x02 0x09 for starting hour (in BCD)

6. Enter **Minute** for start, minute must be the same with actual or higher, and not the past. Two digits in BCD format i.e. 59th should be 0x59. Allowed from 0x00 up to 0x59.

   sudo i2cset -y 1 0x6c 0x01 0x59 for starting minute (in BCD)

7. Use this simple command line (without any python script) to check the entered and stored data at any time. User can write his own simple python script if needed. This line can be executed at any time during entry process.

   sudo i2cget -y 1 0x6c 0x05 && i2cget -y 1 0x6c 0x04 && i2cget -y 1 0x6c 0x03 && i2cget -y 1 0x6c 0x02 && i2cget -y 1 0x6c 0x01 && && i2cget -y 1 0x6c 0x00

Below steps enters Duration of Running and Repetition time.

0x6d -> ETR SAS Actions Running Time Stamp

The second **ETR SAS** registers set is the **Running Time Stamp**, located at **0x6d**. Acording to specification of the 1st Example need to set below values:

Action Duration = 0x0001;	means it will run for 1 minute
Action Repetition Time = 0x02;	means it will be repeated afte 2 minutes from starting time
Action Multiplier = 0x060;	means it will happen 60 times within the same Sequence
Sequence Repetition Time = 0x24;	means this (above described) sequence will be repeated every day (every 24 hours).

The data entering should looks like below (it important to follow the below order to avoid any mistake in programming):

1. Enter **Action_Duration** to specify how long system must running from 1-1439 minutes.

sudo i2cset -y 1 0x6d 0x00 0001 **w** running for 1 minute

2. Enter **Action_Repetition_Time** to define the Repeated Time of the same Action in minutes. Measuring time from beginning of Previous Action to the beginning of the next one

   sudo i2cset -y 1 0x6d 0x02 02 repeated every 2 minutes

3. Enter **Action_Multiplier** to define how many times the **Action** will be repeated within the same **Sequence**

   sudo i2cset -y 1 0x6d 0x03 60 repeated 60 times

4. Enter **Sequence_Repetition_Time** to define Repeated Time of the Saquence

   sudo i2cset -y 1 0x6d 0x04 24 repeated every 24 hours

<u>0x6e -> ETR SAS Actions Stamp</u>

The third **ETR SAS** registers set is the **Actions Stamp**, located at **0x6e**. Acording to specification of the 1st Example need to set below values:

Action RPi_PON = 0x01;	means that Action of this Scheduler will be **Raspberry Pi® ON** and (after Action Duration Time) **OFF**

The data entering should looks like below (it important to follow the below order to avoid any mistake in programming):

2. Enter **Action RPi_PON** to specify what action need to be executed

   sudo i2cset -y 1 0x6e 0x00 01 for RPi_PON = 0x01

<u>0x6f -> ETR SAS Events Stamp</u>

Not involved, as also not implemented in this versionof firmware.

Factory Defaults Setting

UPS PIco HV3.0 HAT is offering feature that allows to revert setting to Factory Default. To do this user has 2 was: based on command line (automatic recall), and manually. Both are described here below.

Command Line Factory (automatic) recall

Then write the following command on the Raspberry Pi command line

Manually Factory Defaults recall

You can do this instead of using the automatic initiation outlined above. However, user need to have physically access to the device, as needs to push buttons.

The following procedure needs to be followed:

- Press and hold the **UR** button
- Continue to hold the **UR** button, and press and hold the **C** button.
- Release the **UR** button, but keep holding the **C** button
- Release after 2 second the **C** button

The User LEDs (all of them) will blinking for a short time, then **UPS PIco HV3.0 HAT** will be restarted. It is mandatory, to have system cable powered during factory recall process (totally about 5 seconds)

UPS PIco HV3.0 HAT settings on Factory Defaults recall

The following setting are setting when Factory Defaults recall.

1. **UPS PIco HV3.0 HAT** EEPROM ERASE
2. **Still Alive Timer** sets to 0xff (OFF)
3. **Hardware RTC** sets to default values:
    - Seconds
    - minutes
4. **FAN Speed** sets to 50%
5. **FAN** sets to Automatic mode
6. **FAN TO92 sensor** temperature sets to 35 Celsius
7. **Auxiliary 5V@750mA** and **3.3V@150mA** sets to OFF
8. **Running on Battery** sets to 60 seconds

9. **A/D converters (setA_D**) sets to mode 0x00 (0-5.2V)
10. **LEDs** sets to be ON when needed (activated by PIco)
11. **UPS PIco HV3.0 HAT Serial Port** sets to OFF (available to use Raspberry Pi® with other applications)
12. **I^{2}C** sets to DEFAULT where used I2C addresses are: 0x68, 0x69, 0x6A, 0x6B, 0x6C, 0x6D, 0x6E, 0x6F
13. **Battery Type** sets to default version of the one stored in the bootloader (LiPO)
14. The **ETR SAS** sets to be de-activated, and values sets to:
    - pico_system.value.active=startTS.var.active=0x00;
    - pico_system.value.min=startTS.var.min=0x00;
    - pico_system.value.hour=startTS.var.hour=0x00;
    - pico_system.value.mday=startTS.var.mday=0x00;
    - pico_system.value.month=startTS.var.month=0x00;
    - pico_system.value.year=startTS.var.year=0x00

A Complete description of the UPS PIco HV3.0 HAT Programmers Registers

The PICo (I²C) Interface - Peripherals I2C Control Interface

The **P**eripherals **I**²C **Co**ntrol – The **PICo Interface** – is an implementation of **I2C** interface adapted to easy control of the peripherals connected to the Raspberry Pi® via simple command line or trough programming language. By using human understandable simple commands, control of the **UPS PIco HV3.0 HAT** peripherals is made extremely simple. Control at programming language level is also possible and easy. The core concept of the **UPS PIco HV3.0 HAT** interface is that all peripheral device control and data exchange between it and Raspberry Pi® variables are common for the **I²C interface** as also for the peripheral itself. Therefore, any change of them by either party, Raspberry Pi® and the peripheral, causes immediate update and action.

Two types of variables are available:

- **Common**, where data are stored in the same place and any change on it will cause action on the **UPS PIco** Module
- **Mirror**, where are copy of data stored on internal variables of the **UPS PIco HV3.0** Module, they are protected, so changes on it will not implies the **UPS PIco HV3.0** Module functionality and will be overwritten immediately when **UPS PIco HV3.0** Module recognized changes on them

There have been implemented the following **PICo** addresses assigned to the following entities:

0x69 ->UPS PIco HV3.0 Module Status Registers Specification

Address	Name	Size	Type	R/W	Explanation
0x00	mode	Byte	Mirror	Read	Powering Mode – Read ONLY, Writing has no effect on the system and will be overwritten by UPS PIco HV3.0 with the new value **Read:** **0x01** - RPI_MODE (means cable powering mode USB or EPR) **0x02** - BAT_MODE
0x08	batlevel	Word	Mirror	Read	Means value of Battery Voltage in 10th of mV in BCD format
0x0a	rpilevel	Word	Mirror	Read	Means value of Voltage supplying RPi on J8 5V Pin in 10th of mV in BCD format
0x0c	eprlevel	Word	Mirror	Read	Means value of Extended Voltage supplying RPi on Extended Voltage input (7-28VDC) in 10th of mV in BCD format
0x0e	curilevel	Word	Mirror	Read	
0x10	curolevel	Word	Mirror	Read	
0x14	aEXT0level	Word	Mirror	Read	Means value of the first A/D converter pre-scaled to 5.2V. Higher voltage could not be supplied. Readings are in 10th of mV in BCD format
0x16	aEXT1level	Word	Mirror	Read	Means value of the second A/D converter pre-scaled to 5.2V. Higher voltage could be supplied with an external resistor divider. Readings are in 10th of mV in BCD format. **If added an extra resistor can be used as pre-scaled to 10, 20 or 30V.**
0x18	aEXT2level	Word	Mirror	Read	Means value of the second A/D converter pre scaled to 5.2V. Higher voltage could be supplied with an external resistor divider. Readings are in 10th of mV in BCD format. **If added an extra resistor can be used as pre scaled to 10, 20 or 30V.**
0x1a	key	Byte	Common	R/W	User Kay Pressed information **Read: 0x01** – Pressed key **A** **Read: 0x02** – Pressed key **B** **Read: 0x03** – Pressed key **C** **Write: 0x00** – Reset (clear) after the current reading and prepare for the next one.
0x1b	ntc	Byte	Mirror	Read	Temperature in Celsius degree of the embedded NTC1 sensor placed on the top of PCB. Values in BCD format.
0x1c	TO92	Byte	Mirror	Read	Temperature in Celsius degree of the TO-92 sensor placed on the bottom of PCB. It is valid only if this sensor is soldered. It is available in the PIco Fan Kit. Values in BCD format.
0x20	charger	Byte	Mirror	Read	Information about charger IC status. **Read: 0x00** – Charger IC is OFF and battery is not charged **Write: 0x01** – Charger IC is ON and battery is charged For Version UPS PIco HV3.0 Stack/TopEnd the charging current is fixed to 300 mA. For Version UPS PIco HV3.0 Plus the charging current is dynamically changed based on powering conditions on micro USB powering input or External Powering Input. The charging current on that version is from 100 mA –

					800 mA. With maximum of the system to be 1200 mA (will be activated in the future). If the **charger** register is set ON, meant that charger circuits has been activated, however if battery is really charged depends to the internal conditions of the charger IC. When current is flowing to the battery (charging) then CHG LED is lighting continuously. It is possible that **charger** register can be read as 0x01, but CHG LED will be off, because system set to charge battery however buttery is full, so no current is flowing. The CHG LED always shows if current is flowing to battery or not. This is valid for all batteries chemistry types.
0x22	pico_is_running	Word	Mirror	Read	It is a 16 bit unsigned variable that value of it, is changing every 1 ms within the main loop of the firmware. Reading two times of this variable must return a different value (with interval longer than 1 ms), if not, means that system hangs-up, and need to be reset, if not restarted by other PIco protection internal mechanism (watch-dog, and supervising watch dog). As these protection mechanisms are always restarting the system when something goes wrong, reason of existence of this variable is just to confirm to the remote user that everything is working well and give feedback to the remote user that system is running properly. As it is a mirror variable, writing to it nothing change, will be again re-written with the newer internal value.
0x24	pv				PCB Version - current available versions: A
0x25	bv				Bootloader Version - current available versions: S - BL_PIco HV 3.0A Stack/TopEnd default LP Battery F - BL_PIco HV 3.0A Stack/TopEnd default LF Battery P - BL_PIco HV 3.0A Plus default LP Battery Q - BL_PIco HV 3.0A Plus default LF Battery
0x26	fv				Firmware Version: current 0x35 dated 01/05/2017

0x6A -> UPS PIco Hardware RTC Registers Direct Access Specification

Address	Name	Size	Type	R/W	Explanation
0x00	seconds	Byte	Mirror	Read	seconds in BCD
0x01	minutes	Byte	Mirror	Read	minutes in BCD
0x02	hours	Byte	Mirror	Read	hours in BCD
0x03	wday	Byte	Mirror	Read	week day in BCD
0x04	mday	Byte	Mirror	Read	month day in BCD
0x05	month	Byte	Mirror	Read	month in BCD
0x06	year	Byte	Mirror	Read	year in BCD

0x6B -> UPS PIco Module Commands

Address	Name	Size	Type	R/W	Explanation
0x00	pico_state	Byte	Common	R/W	**Write: 0xcc** – Unconditional File Safe Shutdown and (and Power OFF when battery powered) **Write: 0xdd** - then restore factory defaults Will stay in the values of 0xdd until factory defaults restored, and then will be set to 0x00 **Write: 0xee** - Reset the UPS PIco CPU, it cause start-up values i.e. RTC will be set to 01/01/2000 **Write: 0xa0 – NORMAL** Sets the I^{2}C addresses used by PIco to 0x68, 0x69, 0x6A, 0x6B, 0x6C, 0x6D, 0x6E, 0x6F **Write: 0xa1 – NO_RTC** Sets the I^{2}C addresses used by PIco to 0x69, 0x6B, and frees the RTC address. This option allows the user to use their own RTC add on. All adresses related to the RTC are free and can be used by other application. **Write: 0xa2 – ALTERNATE** Sets the I^{2}C addresses used by PIco to 0x58, 0x59, 0x5A, 0x5B, 0x5C, 0x5D, 0x5E, 0x5F. This option move the whole registers file to alternate address. This option release the 0x68 address for another RTC for Raspberry Pi if needed, or use it with this address of 0x58. This movement of the registers file frees the other address set for any other application. If PIco HV3.0 RTC is not used, it is mandatory to set time stamp using the 0x6A registers set, in order to use all time (RTC) based functions. The PIco HV3.0 Hardware RTC is located then on the address 0x58. **Write:** 0xFF - Call the UPS PIco Bootloader, Orange Led will be light. Recover from this state can be done **only** by pressing the RST button, new firmware upload or automatically after 16 seconds if nothing happen. All interrupts are disabled during this procedure. It should be used with RPi Uploading firmware script. Use it very carefully and only when is needed – when firmware uploading. Do not play with it; this is not toy functionality. **Powering of the pair UPS PIco+RPi must be done via RPi micro USB socket during boot loading process due to following UPS PIco Resets after firmware uploading or when returning from this mode.** **Due to required protection for the RPi from the unconditional reset (files corruption), it is not possible to enter to this mode when**

					system is powered in a different way than in RPI Powering Mode.
0x01	bat_run_time	Byte	Common	R/W	**On Battery Powering Running Time when cable power loses or not exist. After that time a File Safe Shut Down Procedure will be executed and System will be shut downed without restart. Battery power will be disconnected. System is in sleep mode (LPR) and RTC is running.** **If Raspberry Pi cable power returns again system will be start automatically.** **If during the sleep mode (LPR) the F button will be pressed for longer time than 2 seconds (with battery or cable powering) Raspberry Pi will re-start again.** **Value of 0xff (255) disable this timer, and system will be running on battery powering until battery discharge to 3.4V for LP battery and 2.8V fro LF Battery type.** **Factory default value is 60 seconds** **Each number stands for 1 minute of Battery Running. Default Value is 0, and the highest Value is 0xFE. If user will enter i.e. 2, the Battery Running time will be 60 seconds + 2 x 60 seconds = 180 seconds. After that time system will be shutdown. If user after that will press again F button system will restart and run for 180 seconds again and then shutdown.** **Read:** Anytime, Return actual **fssd_timeout** value **Write:** 0x00 – 0xFF **Any change on this register will cause immediate writing of the new value to the PIco EEPROM**
0x02	rs232_rate	Byte	Common	R/W	Writing to this register sets the UPS PIco HV3.0 Serial Port to the following settings: **0x00 - UPS PIco HV3.0** Serial Port is OFF **Default value** **0x01 - UPS PIco HV3.0** Serial Port is ON and data rate is set to 4800 pbs **0x02 - UPS PIco HV3.0** Serial Port is ON and data rate is set to 9600 pbs **0x03 - UPS PIco HV3.0** Serial Port is ON and data rate is set to 19200 pbs **0x04 - UPS PIco HV3.0** Serial Port is ON and data rate is set to 34600 pbs **0x05 - UPS PIco HV3.0** Serial Port is ON and data rate is set to 57600 pbs **0x0F - UPS PIco HV3.0** Serial Port is ON and data rate is set to 115200 pbs
0x05	STA_timer	Byte	Common	R/W	**Still Alive Timeout Counter in seconds**

					Read: Anytime, Return actual **sta_timer** value **Write:** 0xff – Disable the counter (default value) **Write:** 0x01 – 0xfe Enable and Start down counting of the Still Alive Timer in resolution of 1 second, until reaches value of 0x00 which initiate Unconditional Hardware Reset Procedure **Write**:0x00 – Initiate immediately File Safe Shutdown Procedure and system restart with similar conditions as described below In order to use it as Still Alive (type of watchdog) timer, user needs to upload value from **0x01** to **0xfe** earlier than defined time of seconds. Not uploading of this value will cause System Unconditional Hardware Reset (so System to be Restarted) In order to have this feature working the Gold Plated Reset Pin must be instaled This feature is working on Battery or Cable powering **After execution of the STA Restart the sta_timer is set again to 0xff (disabled).**
0x06	enable5V	Byte	Common	R/W	Defines usage of the Auxiliary 5V@750mA: 0x00 – Auxiliary 5V and 3.3V are not battery backed-up 0x01 – Auxiliary 5V and 3.3V are battery backed-up **Default Values is OFF** **Other codes are not allowed**
0x07	battype	Byte	Common	R/W	Defines used battery chemistry type: 0x46 – LiFePO4 (ASCII: F) used in version Stack/TopEnd 0x51 – LiFePO4 (ASCII: Q) used in version Plus 0x53 – LiPO (ASCII: S) used in version Stack/TopEnd 0x50 – LiPO (ASCII: P) used in version Plus **Other codes are not allowed**
0x08	setA_D	Byte	Common	R/W	Defines the pre scaler of the **AEXT1level** and the **AEXT2level** registers. The 4th MSB bits are responsible for the **AEXT1level** pre-scale, and the 4th LSB bits are responsible for the **AEXT2level** pre-scale. **Read:** Anytime, Return actual **setA_D** value **Write:** 0x00 – 5.2V prescale for the AEXT**2level** **Write:** 0x01 – 10V prescale for the AEXT**2level** **Write:** 0x02 – 20V prescale for the AEXT**2level** **Write:** 0x03 – 30V prescale for the AEXT**2level** **Write:** 0x00 – 5.2V prescale for the AEXT**1level** **Write:** 0x10 – 10V prescale for the AEXT**1level** **Write:** 0x20 – 20V prescale for the AEXT**1level** **Write:** 0x30 – 30V prescale for the AEXT**1level**

					Write: 0xFF – all A/D registers will contain raw data **RED Marked** – not implemented yet
0x09	User LED Orange	Byte	Common	R/W	User LED Orange **ON - Write:** 0x01 User LED Orange **OFF - Write:** 0x00
0x0A	User LED Green	Byte	Common	R/W	**User LED Green ON - Write:** 0x01 **User LED Green OFF - Write:** 0x00
0x0B	User LED Blue	Byte	Common	R/W	User LED Blue **ON - Write:** 0x01 User LED Blue **OFF - Write:** 0x00
0x0C	brelay	Byte	Common	R/W	**Zero Power Bi Stable Relay** **Write:** 0x01 Set **Write:** 0x00 Reset
0x0D	bmode	Byte	Common	R/W	**Integrated Sounder Mode** **Read:** Anytime, Return actual **bmode** value **Write:** 0x00 – Unconditional Disable the Sounder **Write:** 0x01 – Unconditional Enable the Sounder **Default Value:** 0x01
0x0E	bfreq	Word	Common	R/W	**Frequency of sound in Hz**
0x10	bdur	Byte	Common	R/W	**Duration of sound in 10th of ms (10 = 100 ms)**
0x11	fmode	Byte	Common	R/W	**Integrated Fan Running Mode** **Read:** Anytime, Return actual **fmode** value **Write:** 0x00 – Unconditional Disable the FAN with selected speed from the **fspeed** **Write:** 0x01 – Unconditional Enable the FAN FAN with selected speed from the **fspeed** **Write:** 0x02 – Automatic ON/OFF with defined speed in the fspeed, ON when temperature read in sensor T0-92 is higher than **fttemp** threshold, OFF when lower. When UPS PIco is going down to the LPR mode, the FAN is automatically disabled, and enabled again when the UPS PIco returns to normal work Default value is set to 0x02 – Automatic ON/OFF
0x12	fspeed	Byte	Common	R/W	**Integrated Fan Speed** **Read:** Anytime, Return actual **fspeed** value **Write:** 00 – Selected speed when OFF is 0% (not running) **Write:** 100 – Selected speed when ON is 100% (full speed running) **Any other (0-100) number is allowed and means % of speed and current consumption** Default speed is set to 50% **Any data written to this register are stored in the internal EEPROM. So, even if UPS PIco HV3.0 will be reset, will be recovered.**

0x13	fstat	Byte	Mirror	Read	**Read:** Anytime, Return actual **if FAN** is actually running or not (for remote users) When FAN is set to be running (even if not connected physically) the FAN LED is lighting. The intensity of the FAN LED is depending of the FAN Speed (PWM)
0x14	fttemp	Byte	Mirror	R/W	**Integrated Fan Temperature Threshold in Automatic Mode** BCD Fan Running threshold temperature in Celsius, 2 digits i.e. 35, means 35 Celsius. In order to be used (automatic FAN ON/OFF) need to set **fmode** to 0x02. Maximum temperature is 60 Celsius. Higher values will be ignored. FAN will start at 36 Celsius and stop at 35 Celsius. **Read:** Anytime, Return actual **fspeed** value **Write:** 00 – 60 Sets the TO-92 temperature Threshold for the Automatic FAN Start/Stop **Default value is set to 35 Celsius**
0x15	LED_OFF	Byte	Common	R/W	Added LED OFF, that switch OFF all software controlled LEDs. CHG, FAN, EXT can not be switched off as are connected to the hardware and controlled by it. By writing the 0x00 to LEDOFF disable the LEDs. Default is 0x01 (means LED ON)
0x16	SAS_number	Byte	Common	R/W	Define the current ETR SAS that is programmed or read. Default is 0. Allowed number are 0,1,2,3.
0x17	SAS_RUN	Byte	Common	R/W	Specify when **Scheduler** is running or not. Default is 0x00 (not running). Allowed values are 0x00 and 0x01
0x18	Next_Action_Rtime	Word	Mirror	R/W	Specify the minutes of the next Action in minutes if it is less than 24 hours to their execution (1439 minutes or less)
0x19	Time_Scheduler_Selector	Byte	Common	R/W	Selects which **Scheduler** is used: - 0x00 (default) Basic Scheduler - 0x01 ETR SAS Only one can be selected, and each programming is referred to it.
0x1A	BS_duration_time	Byte	Common	R/W	**Basic Scheduler Action Duration Time** in minutes. Allowed values are 0x01 – 0xfe. Default is 0x01
0x1B	BS_repetition_time	Byte	Common	R/W	**Basic Scheduler Action Repetition Time** in minutes. Allowed values are 0x01 – 0xff. Default is 0x02
0x1C	BS_multipier	Byte	Common	R/W	**Basic Scheduler Action Multiplier**. Allowed values are 0x00 – 0xff. Default is 0x01
0x1D	BS_ RUN	Byte	Common	R/W	Specify when **Basic Scheduler** is running or not. Default is 0x00 (not running). Allowed values are 0x00 and 0x01

Events Triggered RTC Based System Actions Scheduler Commands

0x6c -> Start Time Stamp

Address	Name	Size	Type	R/W	Explanation
0x00	active	Byte	Common	R/W	Activation Stamp 0x00 not active (Stop), 0xff active (Start) of current SAS
0x01	minute	Byte	Common	R/W	Starting Minute of hour in BCD - 2 digits (0-59) i.e. 22
0x02	hour	Byte	Common	R/W	Starting Hour of the Day in BCD - 2 digits (0-23) i.e. 22
0x03	mday	Byte	Common	R/W	Starting Day of the Month in BCD - 2 digits (1-31) i.e. 22
0x04	month	Byte	Common	R/W	Starting Month in BCD - 2 digits (1-12) i.e. 12
0x05	year	Byte	Common	R/W	Starting Year in BCD - 2 digits (0-99) i.e. 16
0x06	error	Byte	Mirror	Read	ETR SAS errors

0x6d -> Actions Running Time Stamp

Address	Name	Size	Type	R/W	Explanation
0x00	error	Byte	Mirror	Read	ETR SAS errors
0x01	Duration	Word	Common	R/W	In BCD 4 digits minutes 1-9999
0x03	Repetition	Word	Common	R/W	In BCD 2 digits (1-9999) every XXXX minutes: 0x0000 – not repeated (only once for Duration time, on programed time) 0x0001 – 0x9999 – every 1-9999 minutes i.e. 0x0010 means every 10 minutes

0x6e -> Events Stamp

Address	Name	Size	Type	R/W	Explanation

0x6f -> Actions Stamp

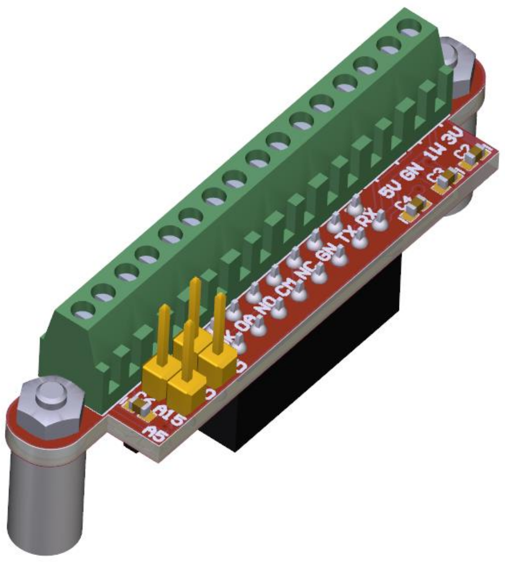
Currently Implemented Only Power Up System – permanently selected.

Address	Name	Size	Type	R/W	Explanation
0x00	RPi_PON	Byte	Common	R/W	Raspberry Pi Power ON Activate: 0x01 Deactivate: 0x00 Default: 0x00 Write 0x01 to have this Action Active and switch Raspberry Pi® Powering ON
0x01	5V_PON	Byte	Common	R/W	Auxiliary 5V@750mA and 3V3 Power ON Activate: 0x01

					Deactivate: 0x00 Default: 0x00 Write 0x01 to have this Action Active and switch Auxiliary 5V@750mA and 3V3 Powering ON
0x02	BR_Set	Byte	Common	R/W	Bi-Stable Relay Set Activate: 0x01 Deactivate: 0x00 Default: 0x00 Write 0x01 to have this Action Active and Set the Bi-Stable Relay

Future implementation: FAN, Charger, Relay, Auxiliary 5V, RPi, Sound, LED,

UPS PIco Terminal Block PCB



User Guide

Designed for the Raspberry Pi® 3

Compatible with

Raspberry Pi® 2, Pi Zero, A+, B+,

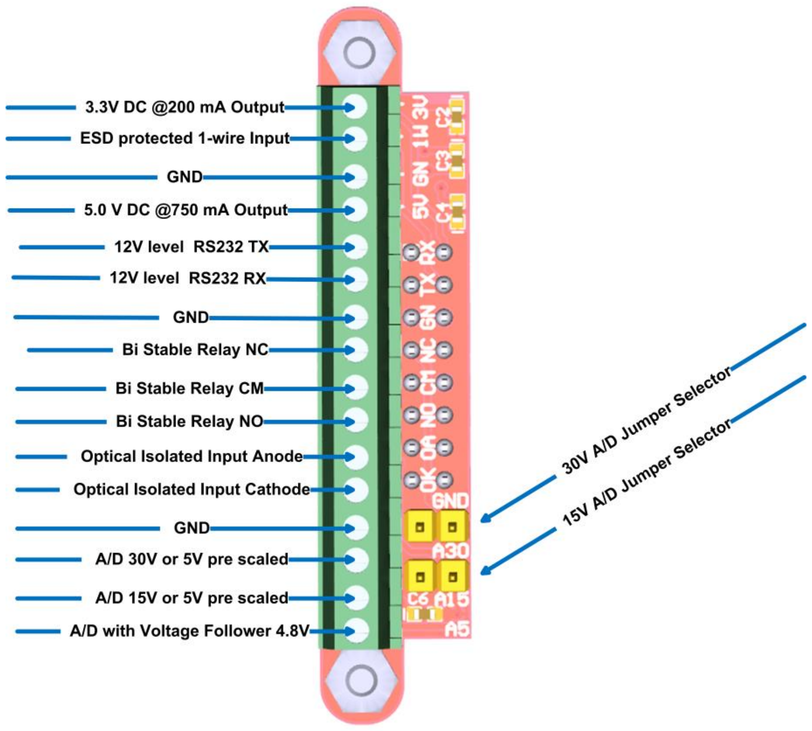
HAT Compliant

Introduction

The **UPS PIco HV3.0 Terminal Blocks PCB** is an advanced Terminal Blocks PCB that adds a wealth of extra functionality and development features to the innovative **UPS PIco HV3.0**!

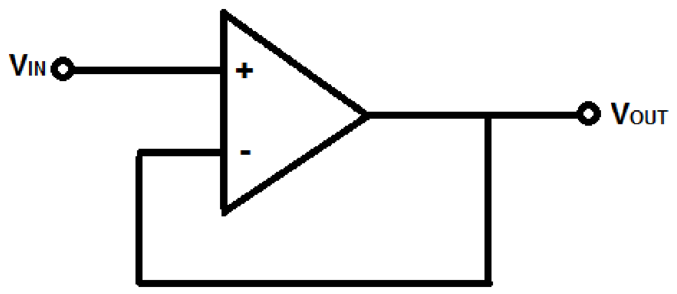
The following listed features are offered by the **UPS PIco HV3.0 Terminal Blocks PCB**:

- Terminal Block Connectivity on Independent from Raspberry Pi, and battery backed-up 3.3 V 200 mA supply (available also when Raspberry Pi is not powered)
- Terminal Block Connectivity on ESD protected 1-wire interface
- Terminal Block Connectivity on Independent from Raspberry Pi and battery backed-up 5V source 750 mA (available also when Raspberry Pi is not powered)
- 12V RS232 Interface Level Converter connectable to the Raspberry Pi Primary Serial Port or Independent Secondary Serial Port offered by UPS PIco HV3.0A with Terminal Block Connectivity
- Terminal Block Connectivity on Auxiliary interface to the bi-stable (zero power) Relay offered by the UPS PIco HV3.0A
- Terminal Block Connectivity on Optical Isolated Interface – readable as digital or analog input offered by the UPS PIco HV3.0A
- Terminal Block Connectivity on ESD Protected 12 bit A/D converters pre-scaled to: 5V, 15V and 30V (user selectable) accessed by I^{2}C on Raspberry Pi®
- Voltage Follower and scaled of 0 - 4.8V A/D with Terminal Block Connectivity


3.3V DC @200 mA Output
ESD protected 1-wire Input
GND
5.0 V DC @750 mA Output
12V level RS232 TX
12V level RS232 RX
GND
Bi Stable Relay NC
Bi Stable Relay CM
Bi Stable Relay NO
Optical Isolated Input Anode
Optical Isolated Input Cathode
GND
A/D 30V or 5V pre scaled
A/D 15V or 5V pre scaled
A/D with Voltage Follower 4.8V
30V A/D Jumper Selector
15V A/D Jumper Selector
3V
1W
GN
5V
C2
C3
C1
RX
TX
GN
NC
CM
NO
OA
OK
GND
A30
C6
A15
A5

What is a Voltage Follower?

A **voltage follower** (also called a unity-gain amplifier, a buffer amplifier, and an isolation amplifier) is an op-amp circuit which has a voltage gain of 1.



This means that the op amp does not provide any amplification to the signal. The reason it is called a voltage follower is because the output voltage directly follows the input voltage, meaning the output voltage is the same as the input voltage. Thus, for example, if 10V goes into the op amp as input, 10V comes out as output. A voltage follower acts as a buffer, providing no amplification or attenuation to the signal.