Strato Pi Logic Controller Advanced Configuration Guide

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MCU firmware version 4.1

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Introduction

This document describes the features of the PIC MCU firmware version 4.0[1] used in the following Strato Pi versions:

- Strato Pi Base
- Strato Pi UPS
- Strato Pi CAN
- Strato Pi CM
- Strato Pi CM Duo.

The MCU firmware implements all low-level control features of the Strato Pi boards, including:

- RS-485 TX-enable management
- Hardware watchdog
- Hardware power cycle or Pi's reset
- UPS management
- Dual microSD card support
- MCU firmware upload from the Raspberry Pi.

Some of these features are only supported on specific models and hardware revisions of the Strato Pi boards.

	RS-485	Watchdog	Power/Reset	UPS	Dual SD	FW upload
Base ≤ 2.2	✔	✔	✔			
Base ≥ 3.0	✔	✔	✔			✔
UPS ≤ 2.2	✔	✔	✔	✔		
UPS ≥ 3.0	✔	✔	✔	✔		✔
CAN	✔	✔	✔			
CM	✔	✔	✔			
CM Duo	✔	✔	✔		✔	✔

A simple ASCII-based serial command protocol between the Raspberry Pi and PIC MCU implements all configuration and control commands.

[1] You can check the factory installed version of the Strato Pi controller firmware from the label attached to the back of the Strato Pi board. After the first two alphabetic characters (representing the assembly facility), the third and fourth are the firmware version and subversion numbers.

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This serial protocol is implemented over two of the Pi's GPIO pins, one used as the TX line and the other as RX. The GPIO pins are specific for each Strato Pi version.

	Pi TX	Pi RX	MCU TX	MCU RX
Base	GPIO13	GPIO19	RB4	RB5
UPS	GPIO13	GPIO19	RB4	RB5
CAN	GPIO13	GPIO19	RB4	RB5
CM	GPIO23	GPIO24	RB4	RB5
CM Duo	GPIO37	GPIO33	RB4	RB5

Communication speed is fixed at 1200 8N1.

The PIC always starts with both AN10/RB4 and AN11/RB5 configured as inputs. When the PIC senses a valid command and has to reply, it will switch AN10/RB4 to output and keep it as output indefinitely.

The different versions of Strato Pi also use different GPIO pins for the various control lines. The following table highlights the features that are controlled by different GPIO pins on different versions:

	Shutdown Enable	Watchdog Enable	Watchdog Heartbeat	Watchdog Timeout
Base	GPIO16	GPIO6	GPIO5	GPIO12
UPS	GPIO16	GPIO6	GPIO5	GPIO12
CAN	GPIO16	GPIO6	GPIO5	GPIO12
CM	GPIO18	GPIO22	GPIO27	GPIO17
CM Duo	GPIO18	GPIO39	GPIO32	GPIO17

MCU	RC3	RB7	RC4	RB6

Command syntax

Commands are always initiated by the Pi. PIC will only reply when a valid command is received.

All commands start with the "X" ASCII character, followed by the command identifier and arguments. No command termination character is required. The PIC replies after the last character forming a valid command and argument is received. It does not reply to an invalid command.

CR/LF characters are always ignored.

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There is a 5 seconds character timeout when receiving commands. If a character is not received for 5 seconds since the previous character, the command buffer will be reset, and the PIC will start looking for a new "X" ASCII command header character.

All commands use upper case characters only. Lower case characters won't match.

The configuration parameters corresponding to commands marked with (*) are retained only until the next power-cycle, unless persisted in memory. If not persisted, the parameters will be reset to the original factory defaults, or to the previously saved user configuration. Refer to the "Permanently saving the current configuration" chapter for more details.

Raspbian software serial implementations

There are a few software serial Linux modules implementations for Raspbian. An open-source module is available on GitHub at: https://github.com/sfera-labs/soft_uart

After the module is compiled and installed, it can be loaded and configured to use the appropriate GPIO pins, for example:

```
sudo insmod soft_uart.ko gpio_tx=13 gpio_rx=19
```

To load the module automatically at boot, add the line:

```
soft-uart
```

to /etc/modules, and create a new file /etc/modprobe.d/soft_uart.conf to set the module options, with the appropriate GPIO numbers, for example:

```
options soft_uart gpio_tx=13 gpio_rx=19
```

The protocol is human readable, you can test it with minicom or any other terminal program:

```
minicom -b 1200 -D /dev/ttySOFT0
```

On a Raspberry Pi Model 3 B+ and Raspbian, it has been tested successfully at speeds up to 19200. Data transfer becomes unreliable at or above 38400.

A different software serial implementation is the pigpio Python module: http://abyz.me.uk/rpi/pigpio/python.html

RS-485 control commands

XSMn - RS-485 TX-Enable Mode (*)

Set the TX-Enable operations mode.

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Command	Description	Reply
XSMA	Set TX-Enable automatic mode (factory default)	XSMA
XSMP	Set TX-Enable passive mode	XSMP
XSMF	Set TX-Enable fixed speed mode. In this mode, TX-Enable timing is based on speed, number of bits, parity and number of stop bits set using the control protocol	XSMF
XSM?	Return current mode	XSMn

XSPrbps - RS-485 communication parameters (*)

Used when TX-Enable operation mode is set to fixed with the XSMF command, must be set to the Pi's UART baud rate, number of bits per character, parity mode and number of stop bits.

Command	Description	Reply
XSPrbps	Set RS-485 communication parameters: speed, number of bits, parity and number of stop bits for TX-Enable fixed speed mode	XSPrbps
XSP?	Return current communication parameters	XSPrbps

For example, the command XSP58N1 sets the communication parameters to the original factory default configuration: 9600 bps, 8 bits, no parity and 1 stop bit.

[r] parameter	Description	Reply
2	1200 bps	XSP2bps
3	2400 bps	XSP3bps
4	4800 bps	XSP4bps
5	9600 bps (factory default)	XSP5bps
6	19200 bps	XSP6bps
7	38400 bps	XSP7bps
8	57600 bps	XSP8bps
9	115200 bps	XSP9bps

[b] parameter	Description	Reply
7	7 bit	XSPr7ps
8	8 bit (factory default)	XSPr8ps

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[p] parameter	Description	Reply
N	No parity (factory default)	XSPrbNs
E	Even parity	XSPrbEs
O	Odd parity	XSPrbOs

[s]	Description	Reply
1	1 stop bit (factory default)	XSPrbp1
2	2 stop bits	XSPrbp2

Shutdown parameters

You can start a delayed power-cycle by rising Raspberry Pi's ShutdownEnable pin.

When ShutdownEnable is set to high for at least one second, Strato Pi will wait 60 seconds (configurable with the XPWnnnnn command) and then power off the Pi board for at least 5 seconds (configurable with the XPOnnnnn command). In the alternative "arm mode", setting ShutdownEnable high will arm the shutdown procedure, but will not start the power-cycle until ShutdownEnable goes low.

After being powered off, the Strato Pi UPS board will supply power to the Raspberry Pi only when the main power source is restored (the XPPA command can change this behavior, so that the Strato Pi UPS board will always power up the Raspberry Pi board after a power cycle, even when powered by the battery).

XPEn - shutdown enable mode (*)

Set the shutdown enable mode.

In the default mode, the power-cycle is activated rising the Raspberry Pi's ShutdownEnable pin.

In the alternative "arm mode", setting ShutdownEnable high will arm the shutdown procedure, but will not start the power-cycle until ShutdownEnable goes low. After the line goes low, Strato Pi will wait 60 seconds (configurable with the XPWnnnnn command) and then power off the Pi board for at least 5 seconds (configurable with the XPOnnnnn command).

Note that, if the watchdog is enabled in "arm mode", it will remain active while ShutdownEnable is high (armed).

Using the alternate "arm mode" a shorter shutdown wait time could be configured, then ShutdownEnable set high immediately before starting the OS shutdown procedure. The ShutdownEnable pin should go low automatically when the CPU is halted, so that the power cycle will occur shortly after. If the shutdown procedure fails to complete, the watchdog will still intervene to prevent an indefinite lock.

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Command	Description	Reply
XPEI	When ShutdownEnable is set to high, Strato Pi will immediately initiate the power-cycle, wait 60 seconds (configurable with XPWnnnnn) and then power off the Pi board for at least 5 seconds (configurable with XPOnnnnn) (factory default)	XPEI
XPEA	Setting ShutdownEnable high will arm the shutdown procedure, but will not start the power-cycle until ShutdownEnable goes low. After the line goes low, Strato Pi will wait 60 seconds (configurable with XPWnnnnn) and then power off the Pi board for at least 5 seconds (configurable with XPOnnnnn)	XPEA
XPE?	Return current shutdown enable mode	XPEn

XPWnnnnn - shutdown wait time (*)

Set the shutdown wait time, in seconds.

Command	Description	Reply
XPWnnnnn	Set the shutdown wait time, in seconds (factory default is 60, XPW00060). Min: 1; Max: 99999	XPWnnnnn
XPW?	Return current shutdown wait time	XPWnnnnn

XPOnnnnn - power-off time (*)

Set the power-off time, in seconds.

Command	Description	Reply
XPOnnnnn	Set the power-off time, in seconds (factory default is 5, XPW00005). Min: 1; Max: 99999	XPOnnnnn
XPO?	Return current power-off time	XPOnnnnn

XPUnnnnn - power-up delay (*)

Set the power-up delay, in seconds.

After being powered off, the Strato Pi board will supply power to the Raspberry Pi (or release the reset line of Raspberry Pi Compute Module) only when the main power source is restored for at least the number of seconds set with XPUnnnnn, or immediately (factory default) if the power-on delay is set to 0.

Command	Description	Reply
XPUnnnnn	Set the power-up delay, in seconds (factory default is 0, XPU00000). Min: 0; Max: 99999	XPUnnnnn
XPU?	Return current power-up delay	XPUnnnnn

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XPPn - power-up mode (Strato Pi UPS only) (*)

Set the power-up mode.

If the ShutdownEnable pin is set to high when the main power is not present, the Raspberry Pi and the whole Strato UPS board will be powered down after the shutdown wait time, and turned on again only when the main power is restored.

You can change this behavior so that only the Raspberry Pi is turned off, and the power is always restored after the power-off time, even if running on battery, with no main power present.

Command	Description	Reply
XPPA	If the ShutdownEnable pin is set to high when the main power is not present, only the Raspberry Pi is turned off, and the power is always restored after the power-off time, even if running on battery, with no main power present	XPPA
XPPM	If the ShutdownEnable pin is set to high when the main power is not present, the Raspberry Pi and the Strato UPS board is powered down after the shutdown wait time, and turned on again only when the main power is restored (factory default)	XPPM
XPP?	Return current power-up mode	XPPn

Watchdog parameters

The watchdog is normally disabled. To enable it, set the WatchdogEnable pin to high (the XWEA command can change this behavior, so that the watchdog is always enabled, and the level of the WatchdogEnable pin is ignored).

While WatchdogEnable is high, the Strato Pi controller will watch for state changes of the WatchdogHeartbeat pin.

You should ensure that WatchdogHeartbeat flips its state between high and low faster than every 60 seconds (the watchdog heartbeat timeout is configurable with the XWHnnnnn command).

If the Strato Pi UPS controller doesn't see WatchdogHeartbeat changing state for more than 60 seconds, it will initiate a shutdown procedure, rising the WatchdogTimeout pin to high, to signal that a watchdog timeout has occurred.

If possible, you should immediately initiate a software shutdown on Raspberry Pi, and set the ShutdownEnable pin to high.

When ShutdownEnable is set to high or 60 seconds after the timeout (configurable with the XWWnnnnn command), Strato Pi will wait 60 seconds more (configurable with the XPWnnnnn command, see the shutdown wait time above), then power cycle the Raspberry Pi.

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XWEn - watchdog enable mode (*)

Set the watchdog enable mode.

Command	Description	Reply
XWED	Watchdog is normally disabled (factory default)	XWED
XWEA	Watchdog is always enabled	XWEA
XWE?	Return current watchdog enable mode	XWEn

XWHnnnnn - watchdog heartbeat timeout (*)

Set the watchdog heartbeat timeout.

If the watchdog heartbeat timeout is not persisted (see the "Permanently saving the current configuration" paragraph), it is reverted to the saved value when the next power-cycle occurs.

This allows, for example, to have a long timeout by default, that is reset to a much shorted value when the application that handles the heartbeat signal has started.

When the watchdog is always enabled (XWEA command), the factory default or user defined configuration of the watchdog heartbeat timeout will be forced to 60 seconds if set to a lower value.

Command	Description	Reply
XWHnnnnn	Set the watchdog heartbeat timeout, in seconds (factory default is 60, XWH00060). Min: 1; Max: 99999	XWHnnnnn
XWH?	Return current watchdog heartbeat timeout	XWHnnnnn

XWWnnnnn - watchdog forced shutdown timeout (*)

Set the watchdog forced shutdown timeout.

Command	Description	Reply
XWWnnnnn	Forced shutdown delay from the moment the timeout is expired and the shutdown cycle has not been enabled, in seconds (factory default is 60, XWW00060). Min: 1; Max: 99999	XWWnnnnn
XWW?	Return current watchdog forced shutdown timeout	XWWnnnnn

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UPS Parameters (Strato Pi UPS only)

In its factory default configuration, Strato Pi UPS doesn't automatically power down the Raspberry Pi when the main power source is not available.

It is the user application that, after being notified that the it is running on battery power via the BatteryPower pin, will have to initiate a delayed power-cycle setting the ShutdownEnable pin to high.

This can be changed with the XUBnnnnn command.

XUBnnnnn - UPS automatic power off (*)

Set the UPS automatic power-off timer.

Command	Description	Reply
XUBnnnnn	Set the UPS automatic power off timeout, in seconds. Strato Pi UPS will automatically initiate a delayed power-cycle (just like when GPIO16 is set high) if the main power source is not available for the number of seconds set with this command. Min: 1; Max: 99999	XUBnnnnn
XUB00000	UPS automatic power off disabled (factory default)	XUB00000
XUB?	Return current UPS automatic power off configuration	XUBnnnnn

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Dual microSD cards routing (Strato Pi CM Duo only)

Strato Pi CM Duo allows the two SD interfaces of the Raspberry Pi Compute Module Lite to be routed to two external microSD cards.

The primary SD interface of the Raspberry Pi Compute Module Lite is called SDX. This interface is used for the SD card where the boot partition must be found to boot the system, and must remain connected to SD card at all times while the OS is running.

A secondary SD interface is called SD1. This interface can be used to connect a second SD card where other, non boot partitions, can be present.

The two microSD slots of Strato Pi CM Duo are called SDA and SDB.

Strato Pi CM Duo has a high speed 2x2 hardware matrix, that can be configured to independently enable the data lines to and from SDX and SD1, and to define which SD slot is routed to SDX and SD1.

The default configuration is to have SDX enabled and routed to SDA, and SD1 disabled. This is the firmware factory configuration, and is also forced in hardware when the MCU pins are high impedance.

Control of the 2x2 matrix is based on three pins of the MCU:

MCU pin	High	Low
RA5	SDX interface enabled (default)	SDX interface disabled
RC0	SD1 interface enabled	SD1 interface disabled (default)
RA4	SDX to SDB SD1 to SDA	SDX to SDA SD1 to SDB (default)

These pins can be directly controlled, or configured to be set to the desired state during the next power cycle, using dedicated commands. It is also possible to configure the watchdog to switch the SDX interface to the other SD card slot if a watchdog timeout occurs.

XSDPn - Power up routing

Set the SDX/SD1 interfaces routing at power up.

Command	Description	Reply
XSDPA	set SDA to SDX bus, SDB to SD1 (RA4 = L) at power up (factory default)	XSDPA
XSDPB	set SDA to SD1 bus, SDB to SDX (RA4 = H) at power up	XSDPB
XSDP?	return SDA/SDB routing mode set for next power up	XSDPn

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XSDRn - run-time SDX/SD1 interfaces routing

Immediately set the SDX/SD1 interfaces routing switch (RA4) to SDA/SDB.

This command can be used only with CMs with embedded eMMC, and only when the SD card routed to SD1 is not mounted. The CM Lite versions running Linux would not tolerate a hot swap of the root file system SD card.

Command	Description	Reply
XSDRA	Immediately set SDA to SDX bus, SDB to SD1 (RA4 = L) (factory default)	XSDRA
XSDRB	Immediately set SDA to SD1 bus, SDB to SDX (RA4 = H)	XSDRB
XSDR?	return current SDX/SD1 routing	XSDRn

XPSDn - Toggle SDX/SD1 interfaces routing at next power-cycle

Toggle the SDX/SD1 interfaces routing switch (RA4) to SDA/SDB at next power-cycle.

Command	Description	Reply
XPSD1	enable boot SD toggle at power cycle	XPSD1
XPSD0	disable boot SD toggle at power cycle (factory default)	XPSD0
XPSD?	return boot SD toggle at power cycle mode	XPSDn

XWSDn - toggle SDX/SD1 interfaces routing after n watchdog resets

Toggle the SDX/SD1 interfaces routing switch (RA4) to SDA/SDB after n consecutive watchdog resets.

Command	Description	Reply
XWSD0	SD switch on watchdog reset disabled (factory default)	XWSD0
XWSDn	(n>0) switch boot from SDA/SDB after n consecutive watchdog resets, if no heartbeat is detected. A value of n > 1 can be used with XWEA only; if the watchdog enable mode is set to XWED, then XWSD1 is forced automatically	XWSDn
XWSD?	return current watchdog SD toggle mode	XWSDn

XSD0n - SDX enable (*)

Immediately enable/disable the SDX interface (RA5).

This command may be used with the CM Lite only with bare-metal OS versions or when the OS runs entirely in RAM, as the OS would not tolerate the hot loss of its file system. It has no effect with CMs with embedded eMMC.

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Command	Description	Reply
XSD01	enable SDX (RA5 = H) (factory default)	XSD01
XSD00	disable SDX (RA5 = L)	XSD00
XSD0?	return SDX enable status	XSD0n

XSD1n - SD1 enable (*)

Immediately enable/disable the SD1 interface (RC0).

Command	Description	Reply
XSD11	enable SD1 (RC0 = H)	XSD11
XSD10	disable SD1 (RC0 = L) (factory default)	XSD10
XSD1?	return SD1 enable status	XSD0n

Permanently saving the current configuration

The configuration parameters corresponding to commands marked with (*) are retained only until the next power-cycle, unless persisted in memory. If not persisted, the parameters will be reset to the original factory defaults, or to the previously saved user configuration.

Note: the Strato Pi controller's permanent memory can only accept up to 100.000 writes throughout the component's lifetime.To prevent damaging the memory the XCCS and XCCR commands should be executed with a frequency such as to avoid exceeding the maximum number of total memory writes.

XCCn - persistent configuration

Permanently save the current configuration as the new factory default, or restore the original factory settings.

Command	Description	Reply
XCCS	Permanently save the current configuration as the new factory default	XCCS
XCCR	Permanently restore the original factory settings	XCCR

Firmware version information

XFW? - read firmware version

Returns the firmware version.

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Command	Description	Reply
XFW?	With firmware versions < 4.0, returns the firmware version. <m> is the major version number, <n> is the minor version number	XFWm.n
	With firmware versions ≥ 4.0, returns the firmware version and hardware model code. <m> is the major version number, <n> is the minor version number, <h> is the numeric hardware model code	XFWm.n/h

Hardware model	Code
Strato Pi Base rev. < 3.0	01
Strato Pi UPS rev. < 3.0	02
Strato Pi CAN	03
Strato Pi CM	04
Strato Pi Base rev. ≥ 3.0	05
Strato Pi UPS rev. ≥ 3.0	06
Strato Pi CM Duo	07

Firmware upload

The firmware upload feature is supported with firmware version 4.0 or later, on Strato Pi Base/UPS revision 3.0 or later and Strato Pi CM Duo.

It is based on a factory pre-loaded boot loader in the MCU.

The boot loader code is stored in the address range 0x0000 - 0x05BF. This area is write protected, and cannot be altered uploading data within this range via the boot loader itself.

The 64 bytes at 0x05C0 - 0x05FF are reserved to the code upload validation.

User firmware is loaded from address 0x0600 up.

The firmware upload process should follow these steps:

- Request firmware upload (boot loader mode)
- Set ShutdownEnable line high[2] and keep it high for at least 5 seconds
- Erase the firmware code validation area, writing the 64 bytes at 0x05C0 - 0x05FF to 0xFF
- Write firmware code from address 0x0600 up, in 64 bytes segments

[2] The ShutdownEnable line is used during the firmware upload process in a different way than the normal request to power cycle the Pi. Here a high to low transition of this line is interpreted as the end of the upload process, and triggers the MCU's reset and restart with the new firmware.

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- Read back the written code for validation
- Confirm the uploaded code by writing the 0x05C0 - 0x05FF validation area
- Set ShutdownEnable line low for at least 5 seconds (or simply shut down the Pi) to reset the MCU and activate the new firmware.

If the MCU is reset (or power-cycled) and the firmware validation area is not correct, the boot loader will automatically enter boot mode, and user firmware will not be executed, effectively disabling all the features in Strato that are controlled by the MCU.

Note that the Raspberry Pi in Strato Pi Base, UPS and CAN will be switched off while the MCU is reset.

On Strato Pi CM and Strato Pi CM Duo, the Compute Module will be reset instead of being switched off. After the reset, SD routing will be set based on the power-up configuration.

XBOOT - enter boot loader mode

Enter boot loader mode.

Command	Description	Reply
XBOOT	If not already in boot loader mode, enter boot loader mode	XBOOTOK
	If already in boot loader mode, remain in this mode	XBOOTIN

XBW - write MCU flash memory

Writes the MCU flash memory, in 64 bytes segments.

This command uses binary data, not only ASCII characters.

Command	Description	Reply
XBW<Ah><Al><D1>...<D64><Ch><Cl>	<Ah> is the most significant byte of the starting address <Al> is the least significant byte of the starting address <D1>...<D64> are 64 bytes <Ch> is the most significant byte of the command checksum (1-complement sum of all data in this command, including the XBW command header <Cl> is the least significant byte of the command checksum	XBWOK XBWKO (error)

XBR - read from MCU flash memory

Read data from the MCU flash memory, in 64 bytes segments.

This command uses binary data, not only ASCII characters.

Command	Description	Reply
XBR<Ah><Al><n>	<Ah> is the most significant byte of the starting address <Al> is the least significant byte of the starting address <n> is the number of bytes to read (1 ≤ n ≤ 64)	XBR<Ah><Al><D1>...<D64><Ch><Cl>

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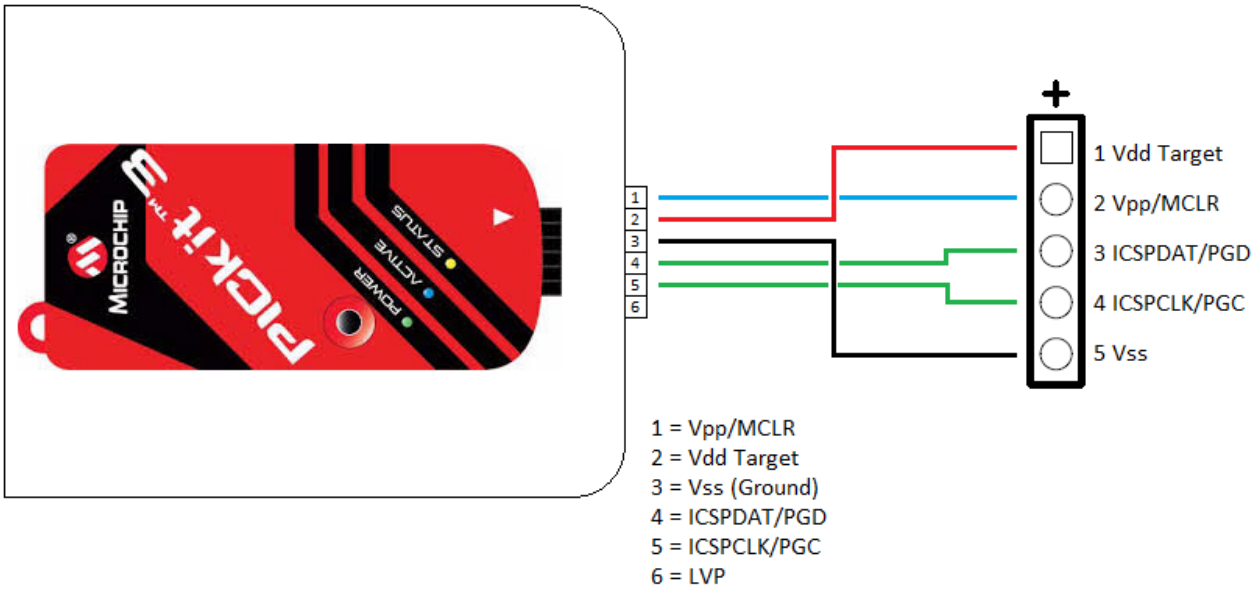
The Strato Pi ICSP header

The Strato Pi Base, UPS, CAN and CM have a programming header that can be used to flash the MCU firmware.

The MCU can be powered from the ICSP header at 3.3V, otherwise the Strato Pi board must be powered through its power supply input.

Note: improper wiring of the ICSP connections, or using a supply voltage different from 3.3V may damage the Strato Pi board, the Raspberry Pi or the programmer, and voids the product warranty.

Note: Sfera Labs is not responsible for malfunction of damage caused by firmware uploaded by the customer.



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Document revision history

- 001 - Nov 24, 2018 - Fw. 3.1
  - Initial public release
- 002 - Jan 4, 2019 - Fw. 3.2
  - New XFW? command: returns the firmware version
  - New XPEn command: shutdown enable mode
  - New XPUnnnnn command: power-up delay (Strato Pi UPS only)
  - ICSP header information added
- 003 - July 1, 2019 - Fw. 3.3
  - Fixed a minor TX-Enable bug that could cause an erratic control of the TX-Enable immediately after switching between passive and automatic mode. Normal operating conditions are restored after a power cycle
- 004 - July 31, 2019 - Fw. 3.4
  - Fixed a bug that caused a false watchdog activation immediately after power-up with the watchdog always enabled (XWEA)
- 005 - September 2, 2019 - Fw. 4.0
  - New Strato Pi CM Duo commands for dual SD card support
  - New firmware upload commands
  - New watchdog forced shutdown timeout command (XWWnnnnn)
  - Hardware model code added in read firmware version command (XFW?) response
- 006 - October 9, 2019 - Fw. 4.1
  - Fixed watchdog heartbeat timeout configuration bug (XWHnnnnn command) introduced in firmware version 4.0 that caused the watchdog heartbeat timeout default setting to be forced to 60 if set to a lower value even when the watchdog was set to normally disabled mode (XWED)

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