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PROTOTYPING ON A PI

Your guide to deploying a Raspberry Pi based prototype straight to Industry

POWERED BY Raspberry Pi

Contents

Prototyping on a Pi

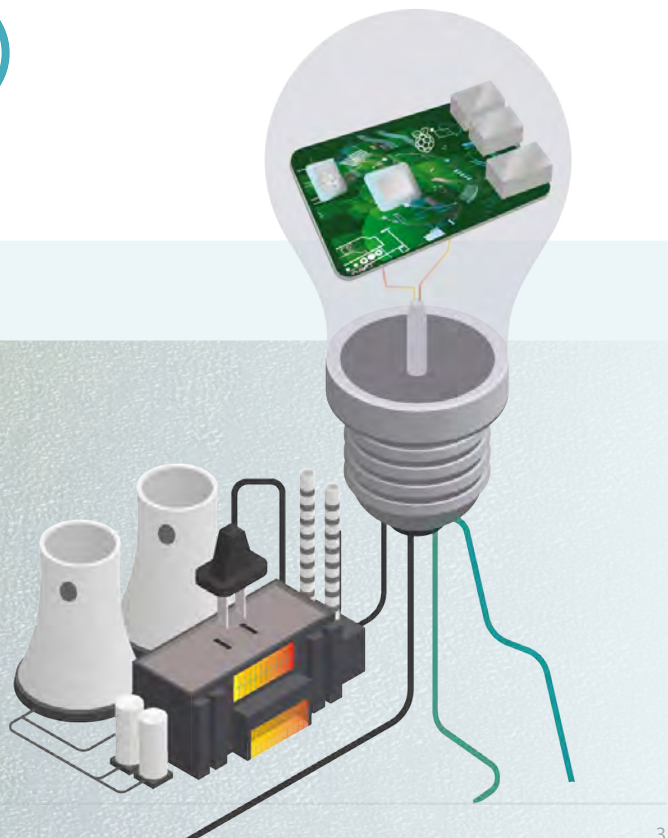
Introduction

Selling over 30 million units worldwide, Raspberry Pi is a single-board computer with fantastic open source software. Originally intended as an educational tool for the teaching of computer science and programming, Pi increasingly finds a place in varied applications from home entertainment over server applications to Industrial Internet of Things (IIoT) projects.

After completing and validating an industrial Pi prototype, engineers are then faced with a decision; switch platforms at the risk of increasing the time to market and the price of the system, or deploy with Raspberry Pi.

This book will highlight some reported issues with Raspberry Pi in factory environments and suggest possibilities for a seamless industrial deployment.

- Can Pi connect to industrial sensors?
- What effect will EMI have on my Pi prototype on the factory floor?
- How does Pi deal with overheating?
- Can Pi survive power loss?
- Industrial power supplies & Pi



CHAPTER 01

Connecting to Industrial Sensors

Raspberry Pi's GPIO pins are designed for driving low current devices such as LEDs, so is it possible to connect to the I/O necessary for industrial environments?

How to Connect Pi to industrial sensors

Sensors and actuators are essential elements of industrial systems, instrumental to any application that requires automated control. Sensors measure changes in the environment, while actuators control physical changes, both devices serve as mediator between the physical environment and the electronic system where they are embedded.

Raspberry Pi provides general purpose header pins that can be connected to sensors, making the low-cost board a popular choice for engineering prototypes. Pi's GPIO pins are designed for driving low current devices such as LEDs however, so is it possible to connect to the I/O necessary for industrial environments?

Raspberry Pi GPIO

What are industrial sensors?

The type of sensors you'll need to connect to your Pi will depend on the particular job your prototype is designed to perform. In manufacturing, the most common processes are concerned with monitoring and control, for example:

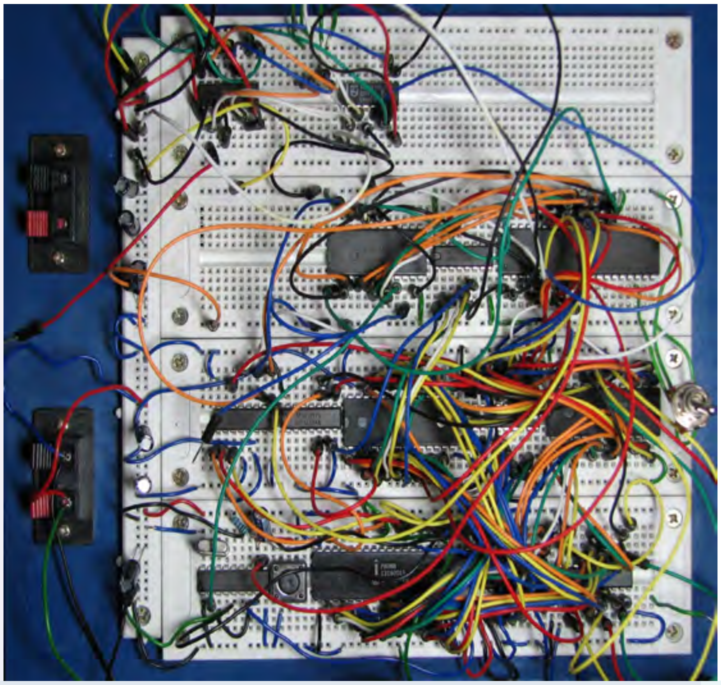
- Temperature: Both contact and contactless sensors can be used to measure temperature.
- Photoelectric: Ideal for counting specific objects using light or lasers.
- Button and Switches: Simple human inputs used to control the functioning of a system.
- Dial: Simple human input providing analogue/continuous control of a signal over a range of values.
- Pressure: Useful for detecting blockages, and signalling when a system needs servicing.
- Vibration: Often the first sign of a problem, sensors that detect changes in vibration are great for predictive maintenance.
- RFID: Used to track and/or locate devices, personnel, and/or equipment.

Industrial sensors typically require 12-24V power and signal changes using the same voltage. Raspberry Pi's GPIO input circuitry can be driven to either 3.3V (high) or 0V (low). This means that whilst a 12V water flow sensor might initially work hooked up straight to a Raspberry Pi, in long-term projects the incompatibility of the currents will almost certainly cause problems.

Does this mean your Pi can't be connected to industrial sensors beyond a prototype?

Connecting a sensor to Raspberry Pi directly often means stripping the sensor's wiring and soldering the cable to the correct GPIO pin. The 12 or 24V of an industrial sensor will then be driven straight to the Pi with nothing in the way to protect Pi's internal circuitry, including the processor. By adding extra circuitry as a buffer between the input pin and the Pi, it is possible to extend the processor's source/ sink current capabilities, and prevent excessive power dissipation in the chip.

Breadboards



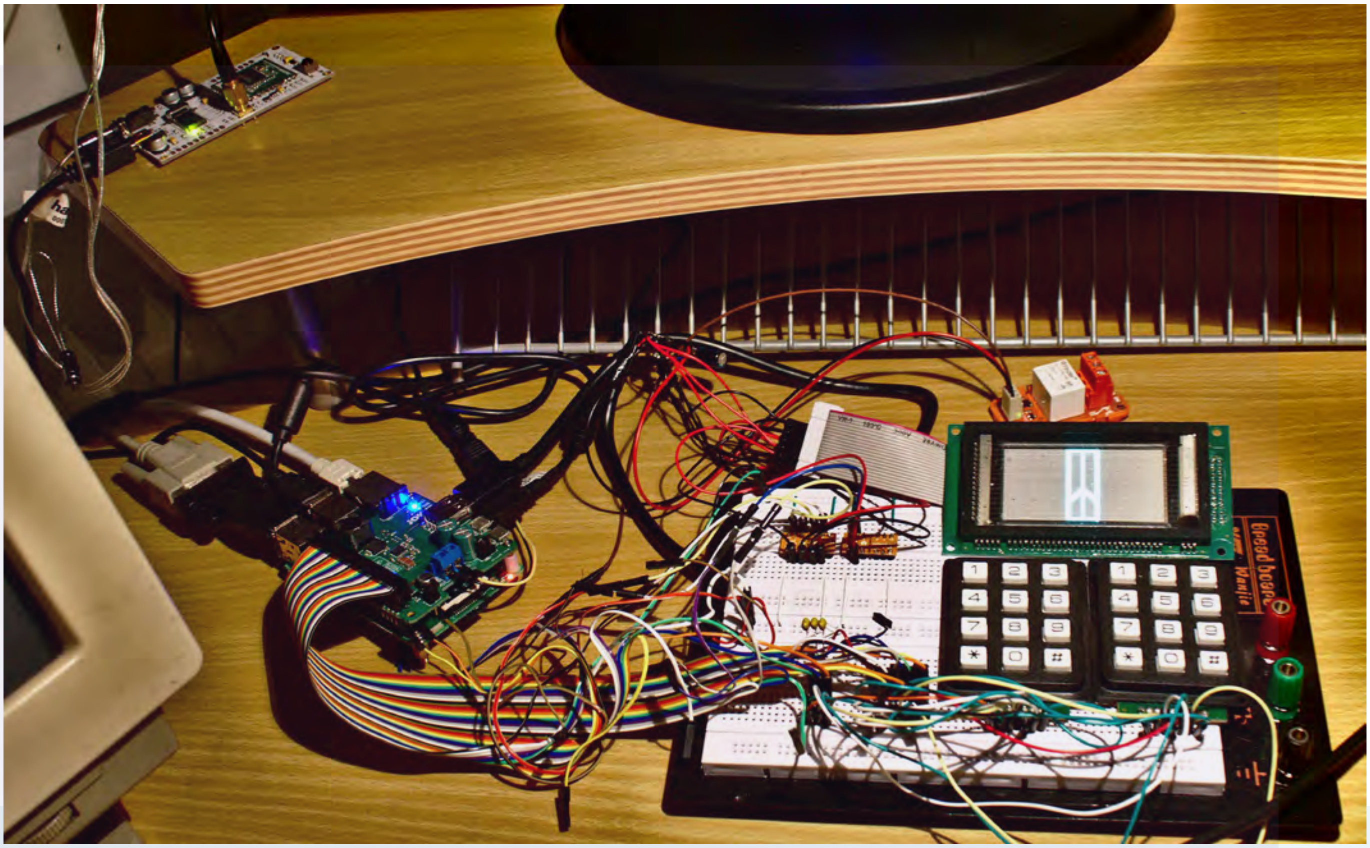
Complex breadboard circuitry

Breadboards are solderless circuit boards that can house even the most complex circuits, making them an invaluable option for prototyping. The impermanence afforded by the boards allows you to build and test multiple circuits without the need to constantly solder rewired connections. In this way, breadboards are great for testing new parts, integrated circuits and for troubleshooting.

Some circuits will require a considerable amount of space, another feature of breadboards that makes them useful tools in industrial prototyping is the ability to extend the surface size by connecting multiples together.

Breadboards & the factory floor

While breadboards can go a long way in adapting Raspberry Pi for industrial applications, certain considerations may be prohibitive to deploying such a prototype directly to a factory environment. The completed set-up is undeniably still a prototype; the connections, whilst providing industrial I/O options, are not optimised for the rigours of the factory floor.



Raspberry Pi attached to breadboards

Industrial Pi

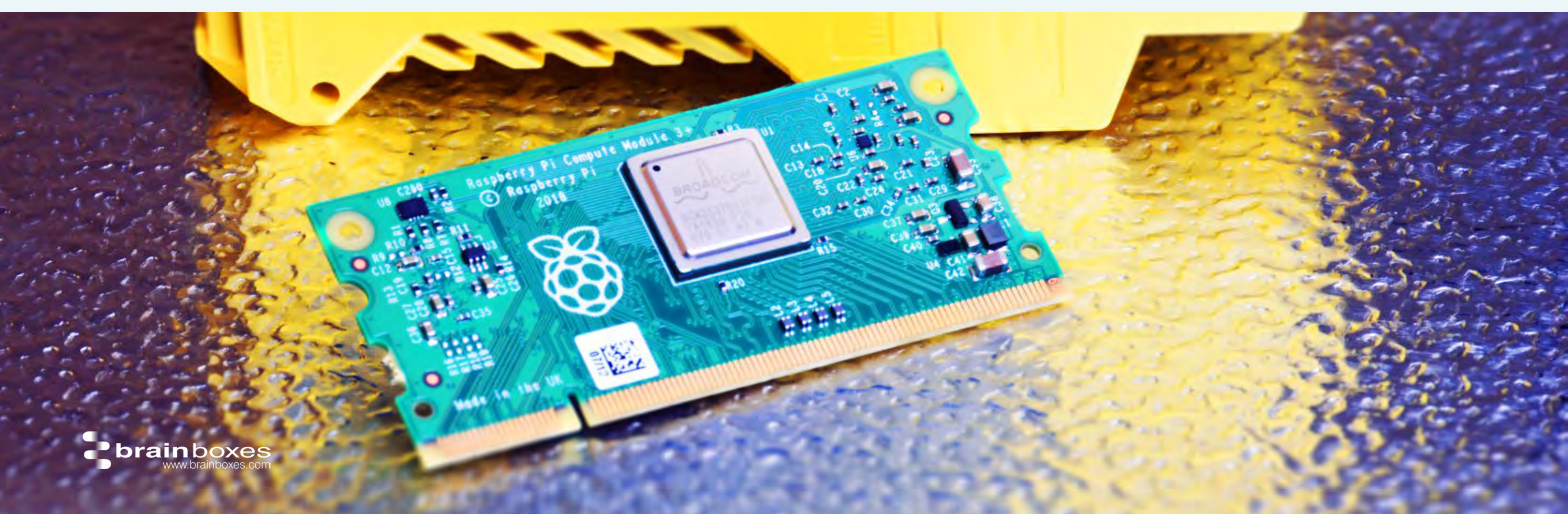
Brainboxes BB-400 is a smart industrial controller that is based around a Raspberry Pi compute module 3+ and allows prototypes to be deployed straight into industrial environments. Rather than adding protection to the GPIO using a breadboard and external circuitry, with the BB-400, sensors and actuators are not wired directly to the Pi, rather electronics between the input pin and the chip do the work which prevents industrial voltages damaging the Pi.

Never Lose a Configuration with Removable Terminal Blocks

Using a screwdriver to connect sensors' wires/ cables into the embedded terminal blocks means that the circuitry doesn't require soldering to create strong and secure connections, and allows multiple reconfigurations. As the terminal blocks can be unplugged, it's easy to take the module out without affecting any of the pre-wired terminals. As a single misplaced component leg can cause the whole circuit to malfunction or even cease to function at all, another useful feature of the terminal blocks is their numbering. It's a lot easier to decipher the correct connection when the need to count down a row of tiny header pins and judge by eye has been eliminated!

The BB-400 has 8 digital I/O connections, making it usable straight out of the box without the need for any add-on units, although there are a variety available if you do find you need more inputs and outputs.

As it is packaged in a DIN rail enclosure, it's the perfect solution for deploying a Raspberry Pi prototype straight onto the factory floor.



CHAPTER 02

Is Pi the Victim of EMI?

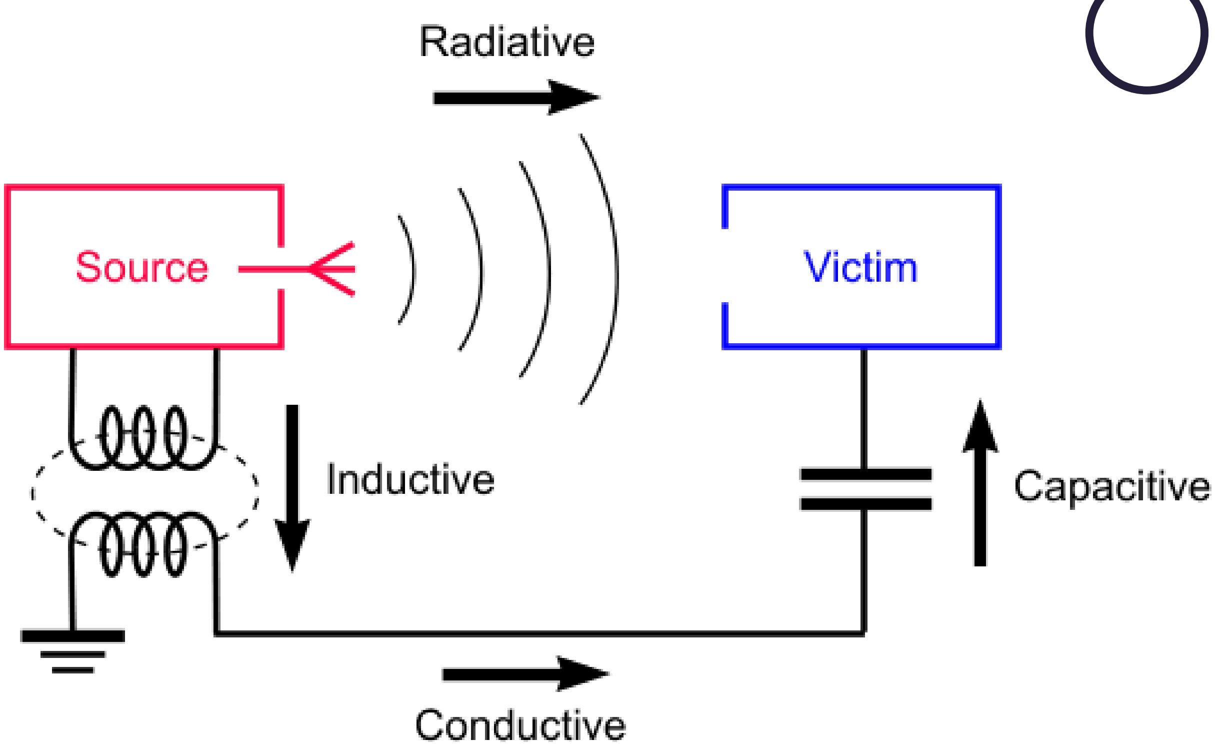
In industrial environments where there will inevitably be a substantial amount of electrical noise, disturbance and unintentional electromagnetic induction, the question we need to ask is, ‘Can Raspberry Pi cope with EMI, and will my prototype achieve acceptable EMC?

Industrial EMC - Is Raspberry Pi the Victim of EMI?

Electromagnetic interference (EMI) is the phenomenon of electrical disturbance that has the ability to negatively affect electrical circuits, whereas EMC, or electromagnetic compatibility, refers to a particular device or piece of equipment, and its ability to limit the generation, propagation and reception of this unwanted electromagnetic energy.

EMC = the control of EMI

In industrial environments where there will inevitably be a substantial amount of electrical noise, disturbance and unintentional electromagnetic induction, the question we need to ask is, ‘Can Raspberry Pi cope with EMI, and will my prototype achieve acceptable EMC?



Electromagnetic transmission

What sources of EMI are present?

Industrial environments are often loud, but it's the silent noise – the electronic disturbance - that can damage the performance of sensors and communications systems or stop them from functioning altogether. The two main types of EMI are conducted and radiated. Conducted emissions are caused by noise generated inside a device which is conducted electrically through the interconnecting cables to other devices.

Radiated interference is when electromagnetic waves are transmitted wirelessly without physical contact of conductors.

With radiated waves, disturbances are not confined to the surface of the conductor, rather will radiate away from it. One type of radiated EMI is near-field interference - capacitive and inductive coupling between two circuits. Near field EMI is never measured by EMC testing, the closest distance at which measurements are taken for EMC testing is 3m which is classed as far-field. However, near-field probes are often used to debug the source of the far-field radiation, so near-field is important when understanding the origin of the radiated noise and how its coupled to the PCB.

A typical factory will house multiple sources of electromagnetic interference; a steel press machine, for example, can be a source of both radiated and conducted emissions: radiated waves generated from collision of the plates or changes in the motor power, whilst signals leak from the power supply on to the AC line to be passed along to other devices. Today's industrial environment with multiple wired and wireless networks connecting machinery together, will have a multitude of machines likely to suffer from EMI emission and susceptibility issues simultaneously.

Every machine and device in the factory is likely both an EMI source and victim.

Is Raspberry Pi EMC tested?

All models of Raspberry Pi have been EMC tested and carry the CE mark for compliance.

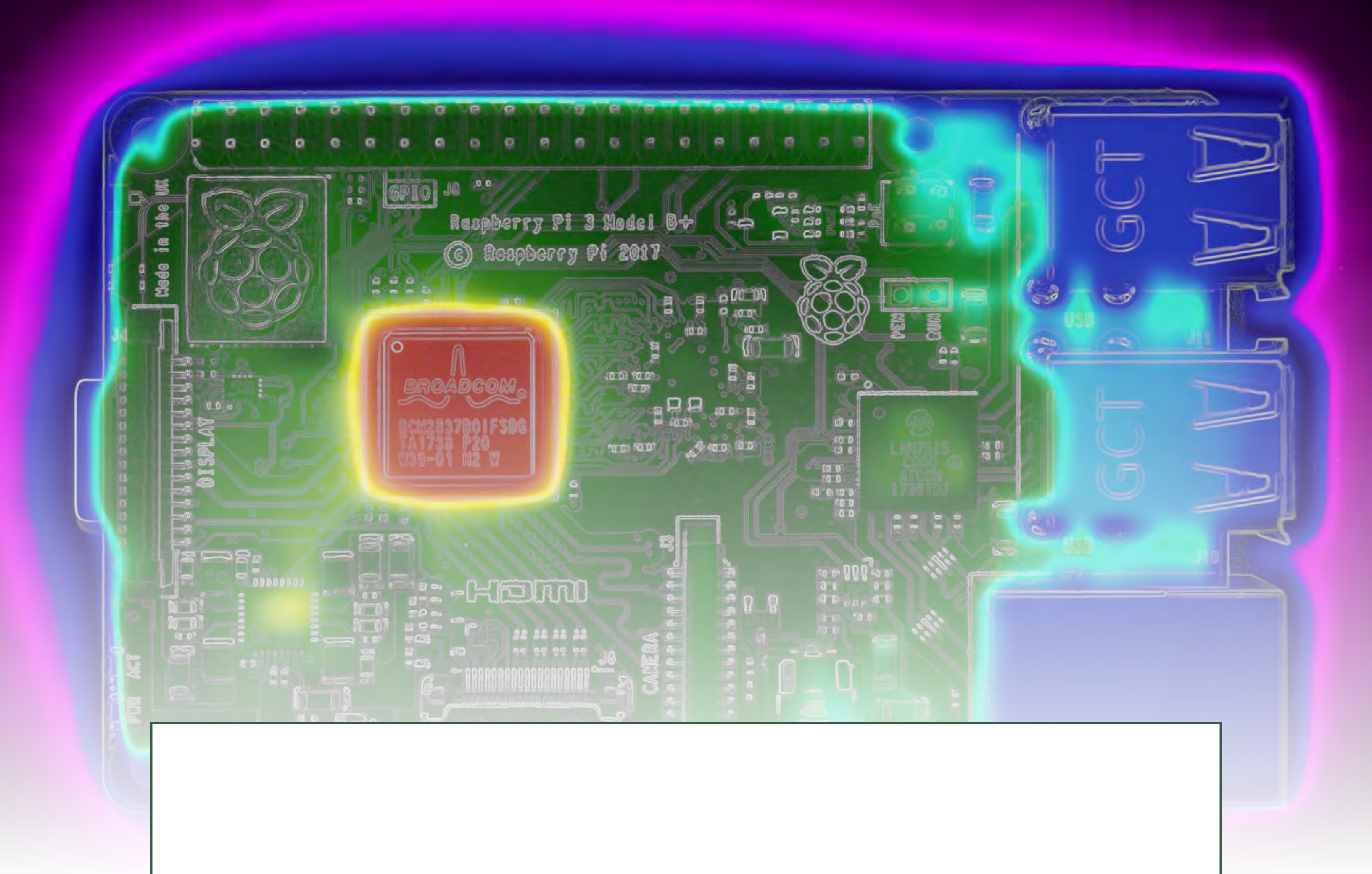
Does this mean your Pi prototype is automatically EMC compliant?

Unfortunately, the answer is no. When the Pi is incorporated into a prototype with added circuitry (such as breadboards) then the whole system would have to be subject to EMC compliance testing as a functional finished unit to achieve CE status. The CE compliance testing Raspberry Pi has undergone relates to the device's EMC and in particular the extent to which it generates unacceptable levels of electromagnetic noise. As the Pi itself is only considered a 'finished product' when it is used in a 'typical configuration' - as a desktop computer – any system that builds on a Pi would require separate compliance testing to establish its suitability for industrial environments. Whilst the Pi out-of-the-box has been certified to not emit significant EMI, the module as with all electronics is still susceptible to interference from its environment.

Is it possible to deploy a Raspberry Pi prototype straight to the factory floor?

There are varied solutions for EMI management – increasing the distance between the source and the susceptible device, rerouting cables, even experimenting with the orientation of devices can limit problems. However, particularly in an environment with many potential sources of interference, the real solution is to ensure equipment is designed to minimize emissions and be less vulnerable to external EMI.
Even if the Pi prototype is housed in a protected place a distance away from sources of radiated emissions, conducted EMI passed through cables will pose a significant risk to the board and prevent its efficient functioning.

By employing a device that is able to protect Pi from EMI it becomes possible to move a prototype straight from a desktop to the factory floor. Brainboxes BB-400 industrial edge controller has undergone rigorous EMC testing with all of the enclosed circuitry included. Testing established that the device doesn't emit significant amounts of EMI itself, and crucially for industrial applications, continues to function as intended in the presence of machines and devices that do.



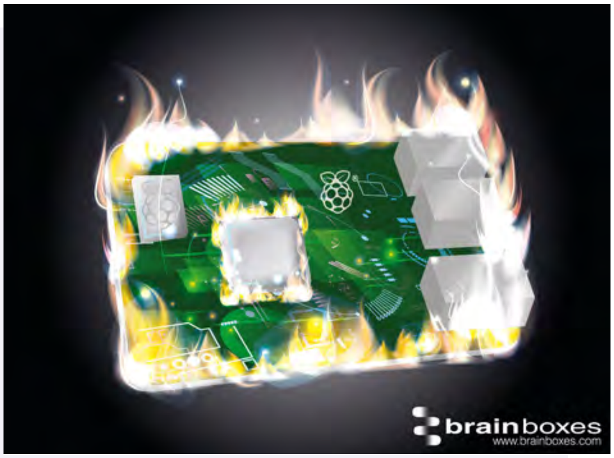
CHAPTER 03

How Hot is Too Hot for Pi?

A reported issue with Raspberry Pi can be overheating, with a resulting loss of performance, when the board is exposed to high temperatures. Fortunately, there are solutions that can prevent Pi overheating, and help deliver optimal performance even in industrial environments.

How Hot is Too Hot - How Does Raspberry Pi Deal with Overheating?

A reported issue with Raspberry Pi can be overheating, with a resulting loss of performance, when the board is exposed to high temperatures.



All electrical devices are qualified to a specific operating temperature range at which the device will work effectively. The operating temperature depends on the specified function and application of the device; and ranges from a minimum to a maximum ambient temperature at which performance is optimised.
Temperatures falling outside of the qualified 'safe' range will risk loss of functionality and in some cases total failure.

What is the maximum operating temperature of Raspberry Pi?

To keep costs low, the Raspberry Pi is built with commercial-grade chips which are qualified to different temperature ranges; the USB and Ethernet controller of the Pi 3+ (Microchip LAN7515) is specified by the manufacturers as being qualified from 0°C to 70°C. The SoC (System on Chip – the integrated circuit that does the Pi's processing, a Broadcom BCM2837B0) is qualified from -40°C to 85°C.

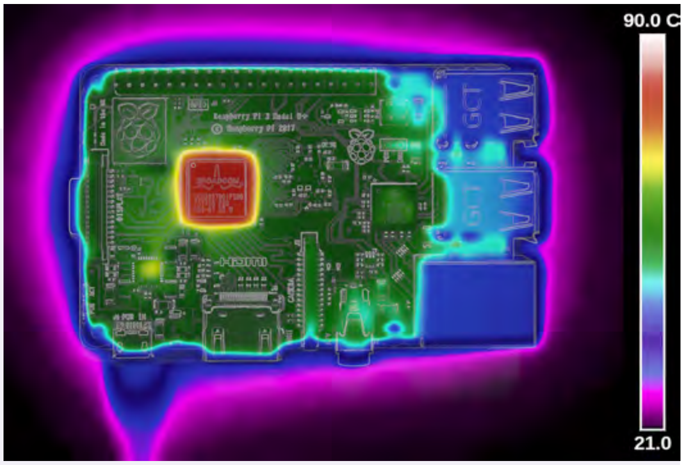
This effectively means that the maximum operating temperature of Raspberry Pi's key components is 70°C and 85°C respectively. In considering the effect of overheating on a Raspberry Pi prototype, it is necessary to consider other sources of heat.
In addition to the ambient temperature, all applications make demands on the Pi's CPU, GPU, and hardware, and as this load increases so does the temperature of the board – particularly to the two key components – the USB and Ethernet controller, and the processor (SoC).

component operating temperature =
ambient temperature + load induced temperature rise

In its typical configuration in stable ambient temperatures, desktop applications – such as internet browsers and office programs like word processors - increase the load induced temperature rise and consequently how hot the components will get.

In industrial environments, a Pi prototype will often be required to function 24 hours a day regardless of the season. In contrast to the typical office environment with air conditioning, industrial environments can have higher ambient temperatures due to factors such as metal roofs that can act as radiators, proximity to industrial ovens and other hot machinery, etc. As Pi's component temperature can reach, and even exceed, the upper level of its operating range whilst sitting on a desk in a temperature-controlled office, an industrial environment with its substantial increase in ambient temperature will inevitably deliver even higher temperatures to the board.

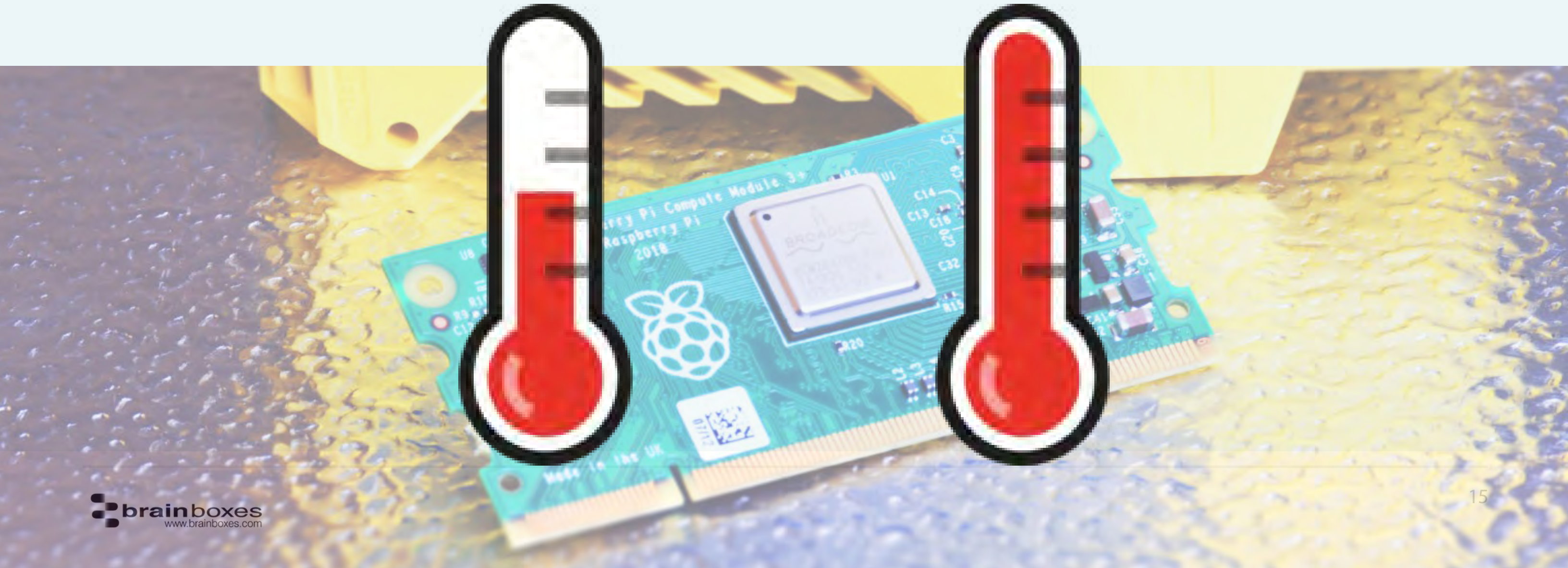
Pi in high temperatures



Raspberry Pi 3+ thermal map

Gareth Halfacree from Bradford, UK [CC BY-SA (https://creativecommons.org/licenses/by-sa/2.0)]

It has been reported that Raspberry Pi can be vulnerable to overheating issues. The thermal map above shows a Raspberry Pi 3+ processor reaching towards 90°C. In some tests, the Pi's SoC has been shown to exceed 100°C. In certain situations, the Pi can be pushed beyond its qualified operating temperature range, therefore its long-term performance is not guaranteed.



CPU Underclocking

CPU underclocking is the process of limiting the frequency at which pulses are used to synchronize a processor's operations. In other words, to deliberately underclock CPU is to consciously reduce the speed of the processor. Underclocking reduces the load-induced temperature rise as slower transistor switching reduces power consumption requirements and therefore generates less heat inside a device.

For Raspberry Pi 3+, a 'soft' temperature limit of 60°C has been introduced. This means that even before reaching the hard limit at 85°C, the clock speed is reduced from 1.4GHz to lower frequencies, reducing the temperature rise to the components. This underclocking increases Pi's system stability at high temperatures, aiming to ensure the operating temperature remains below the 80oC 'safe' level, but this comes at the expense of the processor's performance. When a system deliberately underclocks by throttling the CPU to protect from hardware damage; the speed of the processor is slowed down, which inevitably limits the speed of operations.

slower operations + increased downtime
= decreased profit margins

Increasing Pi's CPU throttling threshold

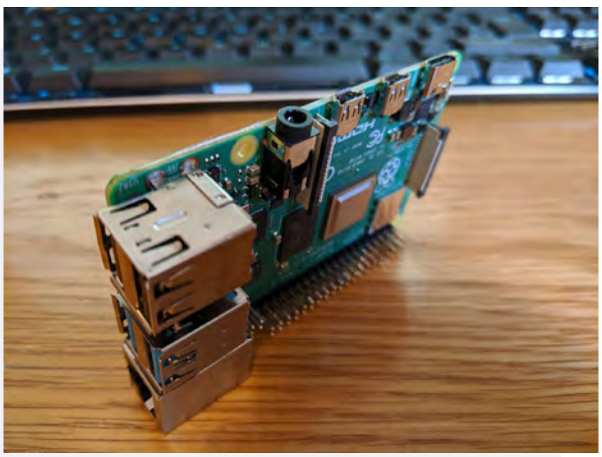
By default, Pi's soft limit is set at 60°C but it is possible to set the temperature at which CPU throttling occurs to a higher threshold value. By adding the line `temp_soft_limit=70` to the /boot/config.txt file, automatic underclocking can be 'postponed' until the Pi reaches a higher temperature.

Whilst Raspberry Pi's CPU is generally capable of withstanding high temperatures for short timescales, continuous operation at the upper end of the range does pose some risk to the longevity of the device

Is underclocking the CPU the only way to avoid Pi overheating?

Fortunately, any solution that decreases the effect of ambient temperature or load induced temperature rise can help keep the SoC under the soft limit without the need to limit the application load or throttle the speed of the processor, even in industrial applications.

Get vertical

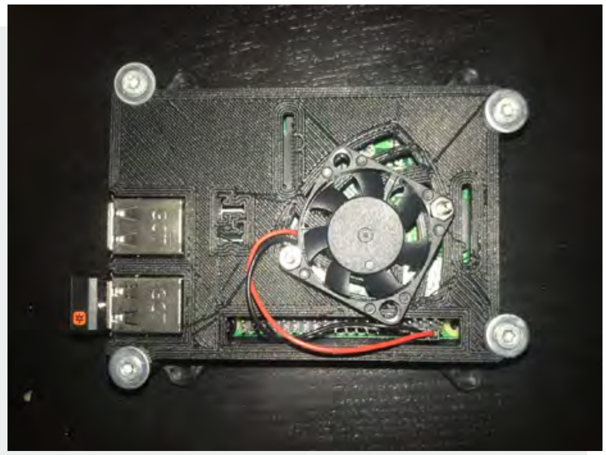


Raspberry Pi 4 in upright position

Raspberrypi.org/blog

By simply moving Pi into an upright orientation with the GPIO header at the bottom and the HDMI ports at the top, management of the ambient temperature will be improved. Orienting the components vertically will have an immediate impact on cooling, and will slow subsequent heating down, as improved convection allows the surrounding air to draw heat away from the board more rapidly. Additionally, the available surface area for cooling is increased by moving the rear of the board away from heat-insulating surfaces.

Install a fan



Raspberry Pi with fan and case

Lorenzo Toscano [CC BY-SA (https://creativecommons.org/licenses/by-sa/4.0)]

If heat can be removed from the components quickly, then the load induced temperature rise will not have an effect on performance. One option to dissipate heat from Pi's components is to mount a cooling fan, powered through the GPIO. Compatible fans are widely available at a relatively low cost and can be positioned to deliver cooling to where it is needed most: the SoC.

For an industrial prototype, however, installing a fan may not be the best solution. Moving parts like fans require maintenance in industrial environments to ensure they don't get clogged with dust. Also, assuming the Pi will be connected to other I/O and possibly extra circuitry in the form of one or more breadboards, the addition of another external element will create a bulky prototype not suitable for deployment straight to the factory floor.

Absorb and dissipate heat with a heat sink

Designed with a maximised surface area to improve contact with a cooling medium – such as air – heat sinks use convection to disperse heat from electronic devices even when no airflow is present.
In developing the model 3+, the Raspberry Pi Foundation elected to fit a metal shield over the SoC to improve convection cooling and dissipate more heat than the model 3.
Whilst tests indicate that the Raspberry Pi with the metal shield (Pi 3+) performs better than without (Pi 3), for industrial applications, the addition of a purpose-designed heatsink can help combat high temperatures and dramatically reduce the temperature of the SoC.

Brainboxes BB-400 with custom aluminium heatsink

Brainboxes designed a custom aluminium heatsink for the [BB-400 Industrial Edge Controller](), that sits in direct contact with the Pi's SoC. The surface area of the heatsink is maximised to most efficiently utilise thermal conduction and draw heat away from the processor. When situated in the industrialised cover, the Raspberry Pi is in a vertical orientation aligned with the vent openings and so also exploits heat convection to provide the highest degree of cooling possible. In addition, the LAN7515 is replaced with an industrial spec chip, making all of the BB-400's components rated for industrial operation (from -25°C to +80°C.)

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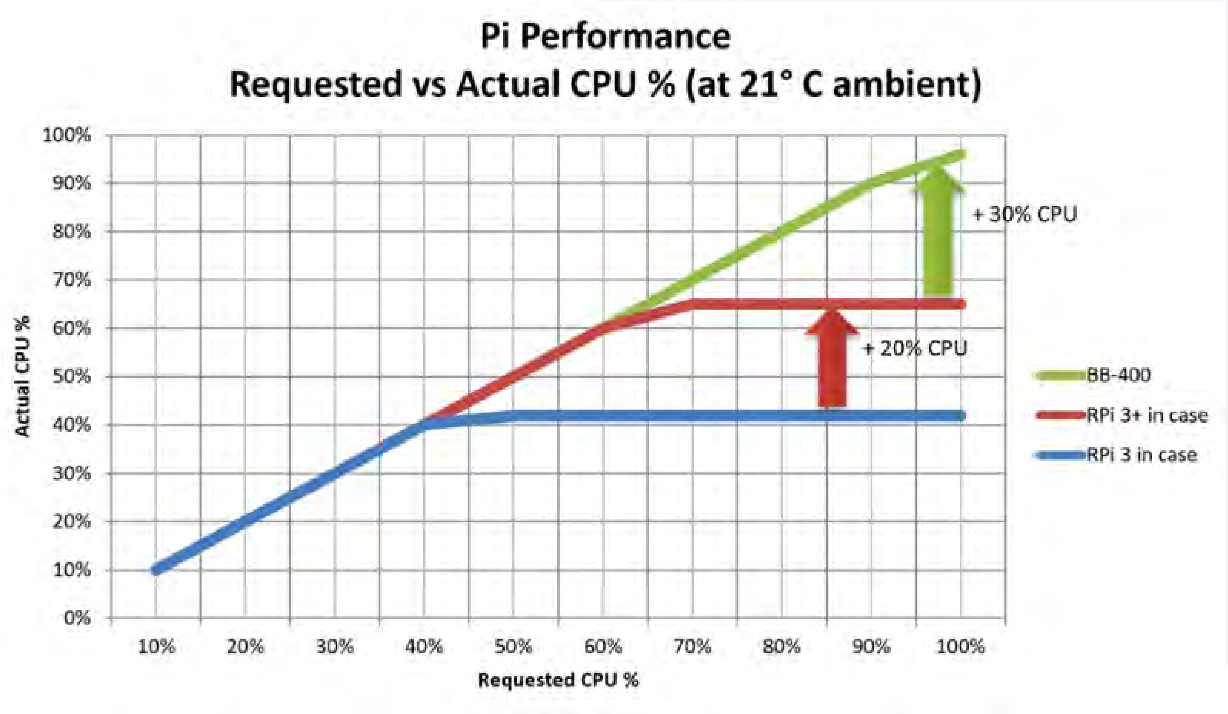
Requested vs Actual CPU

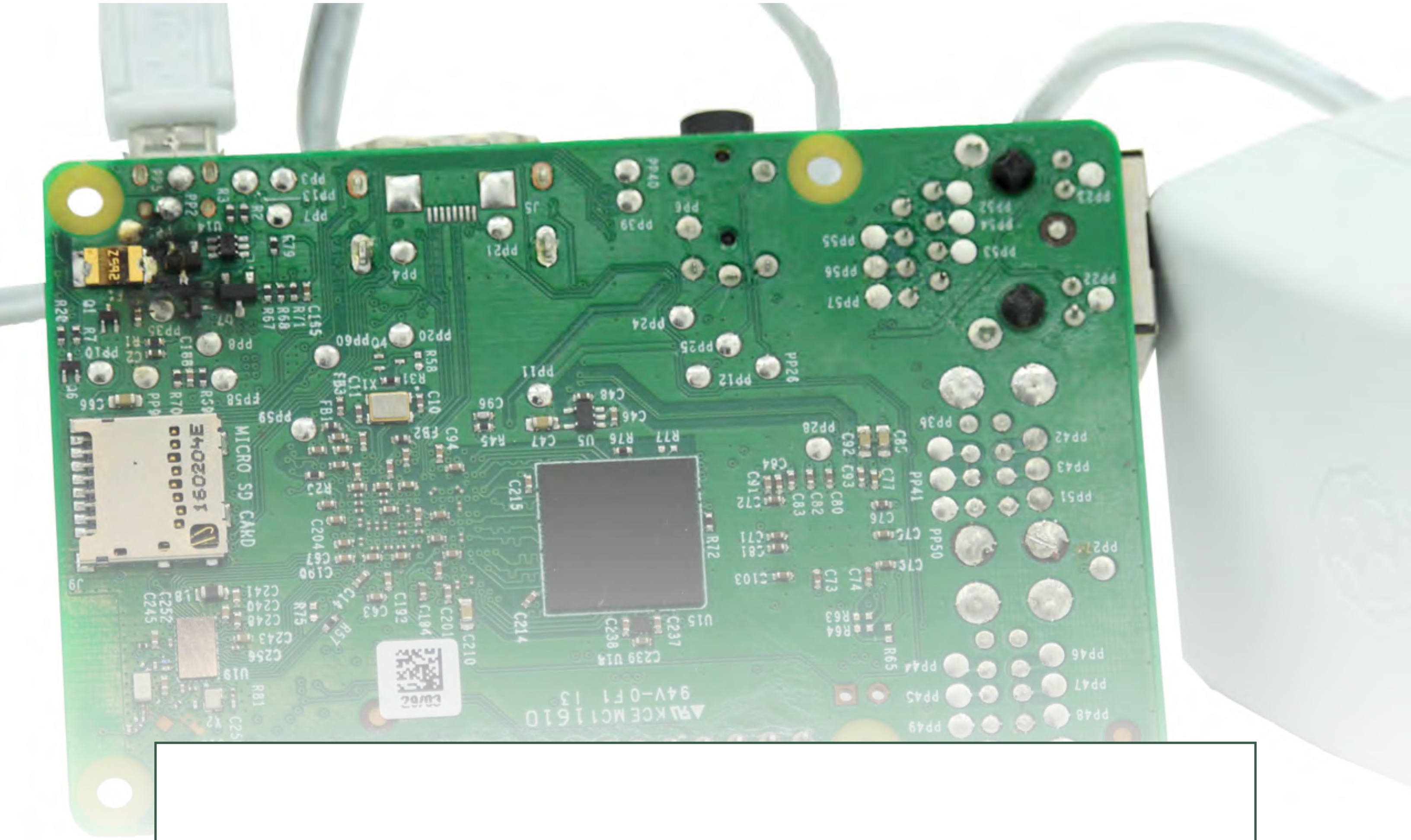
Tests performed at 21°C ambient, actual CPU utilisation recorded after sustained operation:



On the bottom x-axis is the CPU requirements being made by an application – for example, a monitoring application may need 75% CPU utilisation for sustained periods of time to perform its job. On the vertical y-axis is the amount of CPU performance that the Pi is able to deliver. In the absence of throttling, actual performance will track the requested CPU performance on a 1:1 basis, given that CPU throttling only occurs when the component temperature rises. However, processor underclocking due to overheating means that the actual delivered CPU performance can be less than the requested.

The first thing to note is at 21°C, a typical office temperature, the Raspberry Pi 3 without cooling could deliver a maximum of 40% CPU performance for sustained periods of time. The Raspberry Pi 3+ offers a great improvement - due to its metallic lid it can offer up to 65% CPU for sustained periods of time.

The BB-400 with its custom heatsink can deliver 95% CPU performance for sustained periods – ideal to utilise the wonders of Raspberry Pi outside of the environments it was designed for, and making it suitable in industrial settings.

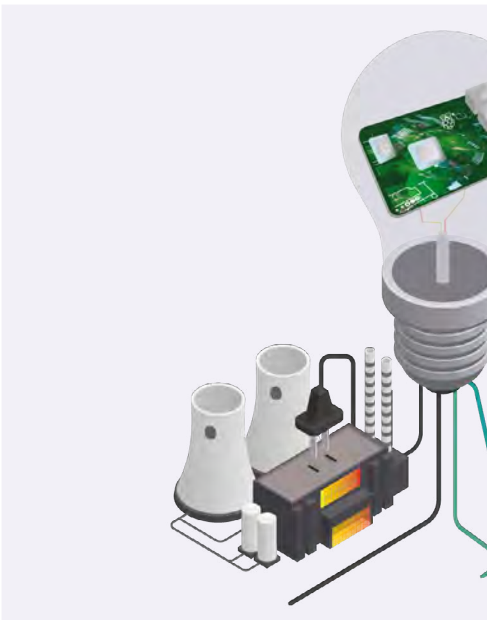


CHAPTER 04

Powering Industry - Industrial Supply & Pi

Raspberry Pi is powered by a very specific +5.1V and 2.5Amps supply - the majority of factories with industrial control applications have power supplies of 12 VDC or 24 VDC. Can Pi power up for industry?

Powering Industry - Industrial Supply & Raspberry Pi



Raspberry Pi is powered by a very specific +5.1V and 2.5Amps supply. In its desktop configuration this requirement is easily met by using any micro USB charger that will provide the exact voltage, though the [official Raspberry Pi power supply]() is recommended.

Raspberry Pi Universal Power Supply

Like most USB power supplies, the official Raspberry Pi PSU is only designed for an office environment and has an operating temperature of 0 - 40°C. In industrial environments where conditions are, as standard, more extreme than the typical office setup, devices are designed to be more robust, and this tends to make industrial power supplies more complex. The majority of factories with industrial control applications have power supplies of 12 VDC or 24 VDC.

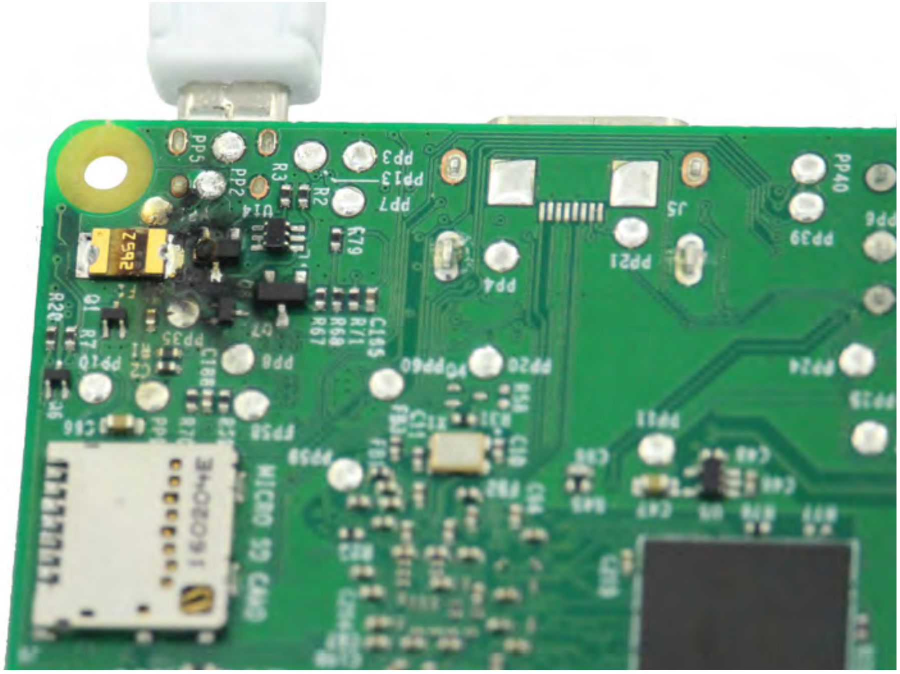
[Official Pi power supply spec.]()

How important is matching the power supply to Pi?

The water analogy so widely used to explain the basics of electricity is effective here in understanding the necessity of matching the power input requirements of a device. If voltage is like water pressure, imagine the flow of electricity to a Pi prototype in terms of water in bathroom pipes.

Too little water pressure and things won't function; too much flowing into a toilet and there's going to be water on the ceiling.

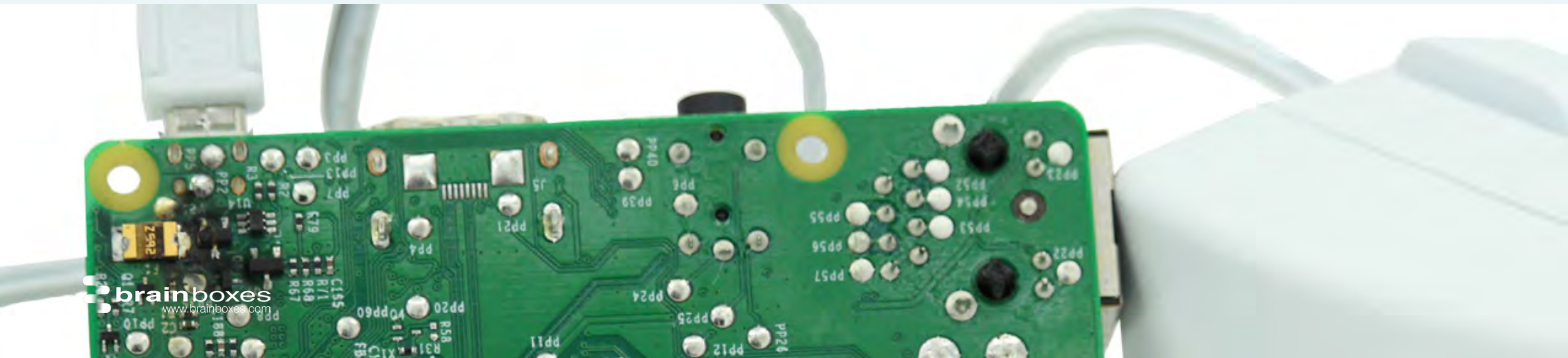
If the power input to Pi is even a few volts over the +5.1V requirement, you risk the stability of operations. Load a substantially higher input (anywhere approaching the 24V typical factory supply) and the board is likely to be damaged or even explode.



Blown power input on Raspberry Pi 3+

Under certain circumstances, the Raspberry Pi firmware will display a warning icon on the display, to indicate an issue.

Undervoltage warning - if the power supply to the Pi drops below 4.63V (+/-5%)



Can Pi survive power loss?

Abruptly stopping the power supply to Pi, as with any computer, can cause issues with memory corruption. The Pi Foundation advise issuing `sudo halt` or `sudo shutdown` commands before pulling the power to ensure any file transactions that are being written to the SD card are completed, the operating system is stopped and the card is no longer active when the Pi loses power.

As with any device with an operating system and memory, if power is interrupted without the chance to issue the recommended shutdown procedure, the system is at substantial risk of file system corruption. The Pi has a limited amount of electrical inertia – energy stored in the capacitors – so if the supply drops, the system will lose power rapidly. In industrial environments where applications can be complex and expensive, this can be disastrous when combined with the vulnerability of the SD card.

When power is restored

Raspberry Pi Ranbow splash screen

Restoring power to an electrical device that has previously lost power is rarely clean, and if Pi's operating system was in the middle of processes when it was stopped abruptly, the resultant corruption can also cause problems when the power comes back on.

As the load is restored; utility picks up and processes restart causing surges and spikes that can damage the SD card and prevent your Pi from booting up.

The 'rainbow' screen shown above is actually four pixels blown up to full screen size, and flashes up as a test of the GPU every time the firmware `start.elf` is loaded. In a functioning Pi, the coloured splash screen is replaced by linux console a second later, so if the screen freezes after restoring power, it suggests the system is failing to boot the `kernel.img` file from an at least partially corrupted SD card.

Can Pi power up for industry?

Though power considerations are relevant to all devices in all applications, electronic prototypes have to meet certain specs to prove their suitability for industrial environments.

Fortunately, there are a wealth of options for adapting Raspberry Pi that can take the versatile board from desk to factory.

Read-only

SD card corruption is caused by power failure occurring as the system is writing to the card, leaving the filesystem in an invalid state. It's worth noting that although your application might not write data itself; the SD card is not automatically safe from corruption as the operating system is constantly writing temporary files, log files, and cache files, amongst others.

Whilst power interruptions can never be completely prevented, one way to make Pi more robust is to limit or stop the amount of writing being done to the SD card.

Forcing the installation into read-only mode safeguards against memory corruption, and significantly prolongs the lifespan of the SD card.

Installing a read-only operating system on the Pi does have downsides however:

- With no persistent system log, if something goes wrong, debugging can be difficult.
- It is not possible to persist state from one boot to the next, although this can be worked around by periodically mounting a second drive via a USB stick.
- With no swap partition, if you run out of memory the likely result is the system will crash.

[Learn how to install Read-Only mode.]

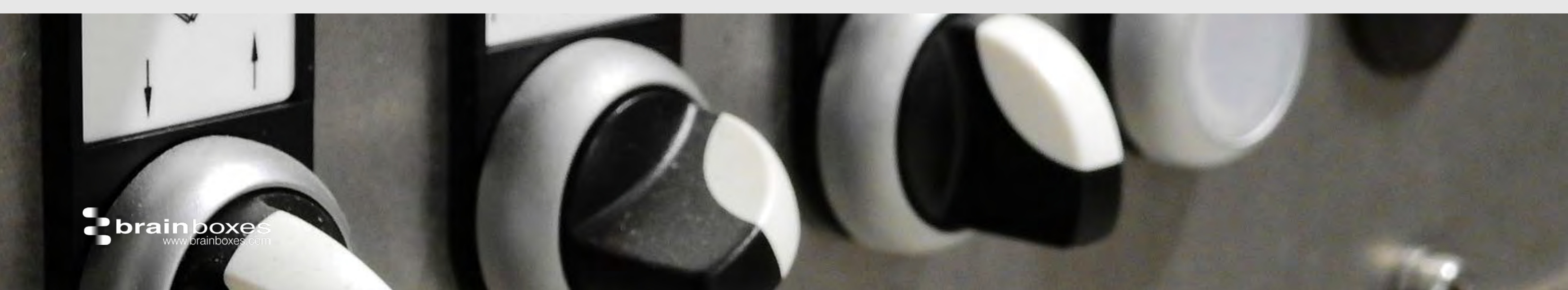
Uninterruptible power supply

An Uninterruptible Power Supply (UPS) is additional equipment that continues to provide power to a device during power interruptions. A UPS system is particularly useful when deploying a Pi prototype into an industrial environment where shutting down systems cleanly is not at the forefront of the mind. In a factory where a common attempted fix for a malfunctioning machine might be to pull the power rather than diagnose the root cause, the resulting corruption issues can cause expensive downtime.

Hardware Attached on Top (or HATs) add specific functionality to Pi, and the options are vast. Dedicated UPS HATs can offer power back-up stability, ensuring Pi will continue to function during any power instability or loss. The advantage of using a UPS HAT is that they are relatively inexpensive and do not need to be permanently soldered to the device. Unfortunately, the addition of a UPS HAT makes it difficult to situate Pi inside a protective case, particularly alongside the further add-ons necessary to industrialise Pi, such as [fans](), RTC (real time clock) HATs, Industrial IO850 etc.

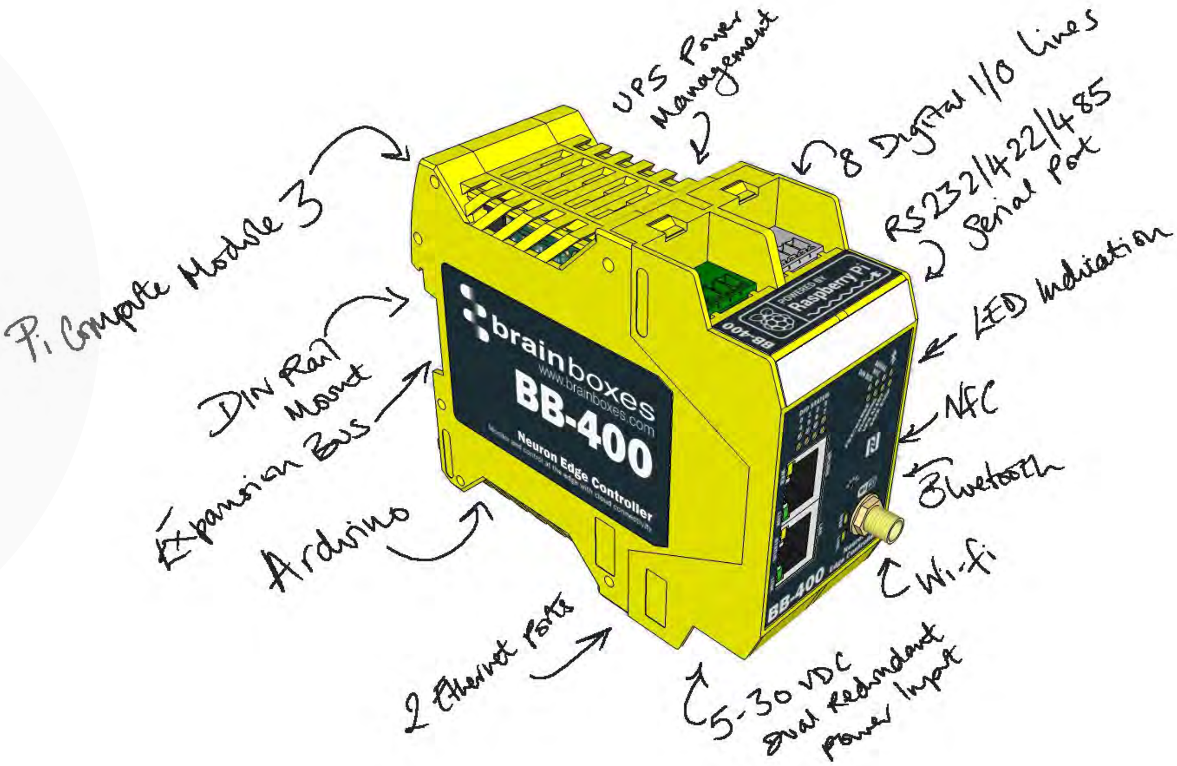
Supply room UPS, both stand-alone and DIN rail options, can also provide back-up power without the need for direct HATs, but these systems can be expensive and servicing can cause unnecessary disruption to your comms room.

Industrial mains power dial



Power management

Brainboxes Industrialised Pi, the [BB-400 Edge Controller](), has a power management unit to monitor and control incoming power to the device and ensure optimum functioning of internal electronics.



Where Pi is powered by +5.1V only, most factories run on power supplies of 12 VDC or 24 VDC. The BB-400 has an input range of 5-30 VDC so can take a Pi prototype straight into an industrial setting.

The power input allows for 2 separate power supplies to be connected at once – a dual redundant supply, meaning that if one power supply fails, the other will take over straight away. There is also a built-in UPS system, using on board super capacitors, which offers clean shutdown if power is interrupted, and an onboard log to document exactly when power failure occurred.

Wide Voltage Input

Dual Redundant Supply

Built in UPS

Prototyping on a Pi

Industrial Raspberry Pi

Retrofitting existing setups and prototypes with smart solutions, particularly out-of-the-box devices, is the most effective way to disrupt the cost of implementing IIoT. Raspberry Pi is a popular low-cost choice for prototyping, and now the limitations of Pi in industry don't have to be prohibitive to its use in IIoT applications.

The BB-400 Industrial Edge Controller equips Pi with hardware fit for purpose, an industrial Raspberry Pi that eliminates the need to gamble with a system that doesn't meet specs.

- 8 Digital IO lines
- Works with common 0-30V sensors
- 1 Ethernet port for wider network
- Extendable Wi-Fi antenna
- Bluetooth - for wireless sensors
- UPS power management - prevents corruption
- Dual redundant 5-30 VDC power supply
- Raspberry Pi Compute 3+ module and Arduino
- Edge processing send relevant data
- Highly compatible open source software
- Program in your favourite language or use out-of-the-box

SHOP BB-400

http://www.brainboxes.com

BB-400 Industrial Edge Controller

Unlock the potential of your application with out-of-the-box, robust connections for equipment of all types & ages

Realtime IO - in an industrial setting you need instant responses. With a dedicated Arduino onboard, the BB-400 monitors & controls I/O lines in real time

Power Supply - the BB-400 has a power management system that's able to supply the right voltage to the Pi. Uninterruptible Power Supply and 5-30VDC Dual Redundant Power input make it a perfect fit for the factory floor

Heat Dissipation - industrial products need to handle high temperatures. A custom heatsink over the Pi brings the BB-400 up to spec; tests indicate no throttling even at 100% CPU usage

About the Authors

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Brainboxes design and manufacture industrial data and IO connectivity products. We are at the forefront of developments in Industrial Internet of Things (IIoT), serial and remote IO technology supplying customers seeking mission-critical industrial automation and test and measurement solutions.

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Prototyping on a Pi

Resources

[Industrial Internet of Things Guide]

[BB-400 Product Page]

[BB-400 Industrial Edge Controller Datasheet]

[BB-400 Industrial Edge Controller Quick Start Guide]

[What Are the Heatsink Capabilities of the BB-400?]

[How Do I Send Serial Data Straight to the Cloud?]

[What is Edge Computing?]

[An Introduction to Cloud Connectors]

[BB-400 Release Notes January 2020]

[Brainboxes Commitment Pledge]

[Brainboxes Case Studies]

[Latest Software downloads]

[Raspberry Pi Blog]

[The Pi Hut - Raspberry Pi Store]

[Official Raspberry Pi power supply]

[Official Raspberry Pi power supply spec.]

[How to Install Read-Only Mode on Pi]

[Node-RED Programming Tool]