Raspberry Pi

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The **Raspberry Pi** is a credit-card-sized single-board computer developed in the UK by the Raspberry Pi Foundation with the intention of stimulating the teaching of basic computer science in schools.[6][7][8][9][10]

The Raspberry Pi is manufactured through licensed manufacturing deals with Element 14/Premier Farnell and RS Electronics. Both of these companies sell the Raspberry Pi online. [11]

The Raspberry Pi has a Broadcom BCM2835 system on a chip (SoC),[3] which includes an ARM1176JZF-S 700 MHz processor (The firmware includes a number of "Turbo" modes so that the user can attempt overclocking, up-to 1 GHz, without affecting the warranty),[4] VideoCore IV GPU,[12] and originally shipped with 256 megabytes of RAM, later upgraded to 512MB.[13] It does not include a built-in hard disk or solid-state drive, but uses an SD card for booting and long-term storage.[14] The Foundation's goal is to offer two versions, priced at US$ 25 and US$ 35. The Foundation started accepting orders for the higher priced model on 29 February 2012.[15]

The Foundation provides Debian and Arch Linux ARM distributions for download.[16] Also planned are tools for supporting Python as the main programming language,[17][18] with support for BBC BASIC,[19] (via the RISC OS image or the "Brandy Basic" clone for Linux),[20] C,[17] and Perl.[17]

Raspberry Pi	
"Raspberry Pi" Computer Model-B Rev1	
Developer	Raspberry Pi Foundation
Type	Single-board computer
Release date	29 February 2012[1]
Introductory price	US$ 25 (model A) and US$ 35 (model B)
Operating system	Linux (Debian GNU/Linux, Fedora, and Arch Linux ARM)[2] RISC OS, FreeBSD, Plan 9
Power	2.5 W (model A), 3.5 W (model B)
CPU	ARM1176JZF-S (armv6**k**) 700 MHz,[3] Raspberry PIs can dynamically increase clockspeeds, and some can temporarily reach speeds up to 1 GHz.[4]
Storage capacity	SD card slot (SD or SDHC card)
Memory	256 MByte (Model A) 512 MByte (Model B rev 2)[5] 256 MByte (Model B rev 1)
Graphics	Broadcom VideoCore IV[3]
Website	www.raspberrypi.org (http://www.raspberrypi.org)

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History

An early alpha-test board in operation. Its layout is different from the beta and production boards.

In 2006, early concepts of the Raspberry Pi were based on the Atmel ATmega644 microcontroller. Its schematics and PCB layout are available for public download.[21] Foundation trustee Eben Upton assembled a group of teachers, academics and computer enthusiasts to devise a computer to inspire children.[22] The computer is inspired by Acorn's BBC Micro of 1981.[23] The first ARM prototype version of the computer was mounted in a package the same size as a USB memory stick.[24] It had a USB port on one end and a HDMI port on the other.

Pre-launch

In August 2011, fifty Alpha boards were manufactured. These boards were functionally identical to the planned model B,[25] but were physically larger to accommodate debug headers. Demonstrations of the board showed it running the LXDE desktop on Debian, *Quake 3* at 1080p,[26] and Full HD MPEG-4 video over HDMI.[27].

In October 2011, a version of RISC OS 5 was demonstrated in public, and following a year of development the port was released for general consumption in November 2012.[28][29][30][31]

In December 2011, twenty-five model B Beta boards were assembled and tested[32] from one hundred unpopulated PCBs.[33] The component layout of the Beta boards was the same as on production boards. A single error was discovered in the board design where some pins on the CPU were not held high; it was fixed for the first production run.[34] The Beta boards were demonstrated booting Linux, playing a 1080p movie trailer and the Rightware Samurai OpenGL ES benchmark.[35]

Certificate of authenticity for an auctioned board

During the first week of 2012, the first 10 boards were put up for auction on eBay.[36][37] One was bought anonymously and donated to the museum at The Centre for Computing History in Suffolk, England.[38][39] The ten boards (with a total retail price of £220) together raised over £16,000,[40] with the last to be auctioned, serial number No. 01, raising £3,500.[41] In advance of the anticipated launch at the end of February 2012, the Foundation's servers struggled to cope with the load placed by watchers repeatedly refreshing their browsers.[42]

Launch

The first batch of 10,000 boards was manufactured in Taiwan and China,[43][44] rather than in the UK. This is in part because import duty is payable on individual components but not on finished products. Chinese manufacturers also quoted a lead time of four weeks, compared to 12 weeks in the UK. Savings can be reinvested in the Foundation's research and development activities.[44]

Shipping delays for the first batch were announced in March 2012, as the result of installation of an incorrect Ethernet port.[45][46] But the Foundation expects that manufacturing quantities of future batches can be increased with little difficulty if required.[47]

> "We have ensured we can get them [the Ethernet connectors with magnetics] in large numbers and Premier Farnell and RS Components [the two distributors] have been fantastic at helping to source components," Upton said.

Initial sales commenced 29 February 2012[48] at 06:00 UTC;. At the same time, it was announced that the Model A, originally to have had 128 MB of RAM, was to be upgraded to 256 MB before release.[15] The Foundation's website also announced "Six years after the project's inception, we're nearly at the end of our first run of development – although it's just the beginning of the Raspberry Pi story."[49] The web-shops of the two licensed manufacturers selling raspberry PI's within the United Kingdom, Premier Farnell and RS Components, had their websites stalled by heavy web traffic immediately after the launch.[50] At one point the webmaster pleaded, "Guys – can you please stop hitting F5 on our website quite so often? You're bringing the server to its knees."[51] Although as yet unconfirmed, reports suggest that there are over two million expressions of interest or pre-orders.[52] The official Raspberry Pi Twitter account reported that Premier Farnell sold out within a few minutes of the initial launch, while RS Components took over 100,000 pre orders on day one.[15] As of September 2012, about 500,000 boards have been sold.[53]

Manufacturers were reported in March 2012 to be taking a "healthy number" of pre-orders.[54]

Post-launch

On 16 April 2012 reports started to appear from the first buyers who had received their Raspberry Pi.[55][56] As of 22 May 2012 over 20,000 units have been shipped.[57] On 16 July 2012 it was announced that 4000 units were being manufactured per day, allowing Raspberry Pis to be bought in bulk.[58][59] On 5 September the Raspberry Pi Foundation announced a second revision of the Model B Raspberry Pi.[60] On 6 September 2012 it was announced that going forward the bulk of Raspberry Pi units would be manufactured in the UK, at Sony's manufacturing facility in Pencoed, Wales. The foundation estimates the plant will produce 30,000 units per month, and will create about 30 new jobs.[61][62] In October 2012 it was reported that some customers of one of the two main distributors had been waiting more than six months for their orders. This was reported to be due to difficulties in sourcing the CPU and conservative sales forecasting by this distributor.[63]

Hardware

Initial sales are of the Model B, with plans to release the Model A in early 2013. Model A has one USB port and no Ethernet controller, and will cost less than the Model B with two USB ports and a 10/100 Ethernet controller.[64]

Though the Model A doesn't have an RJ45 Ethernet port, it can connect to a network by using a user-supplied USB Ethernet or Wi-Fi adapter. There is in reality no difference between a model A with an

external Ethernet adapter and a model B with one built in, because the Ethernet port of the model B is actually a built-in USB Ethernet adapter. As is typical of modern computers, generic USB keyboards and mice are compatible with the Raspberry Pi.[14]

The Raspberry Pi does not come with a real-time clock,[7] so an OS must use a network time server, or ask the user for time information at boot time to get access to time and date for file time and date stamping. However, a real-time clock (such as the DS1307) with battery backup can be added via the I²C interface.

On 20 April 2012 the schematics for the Model-A and Model-B were released by the Raspberry Pi foundation.[65]

Hardware accelerated video (H.264) encoding became available on 24 August 2012 when it became known that the existing license also covered encoding. Previously it was thought that encoding would be added with the release of the announced camera module.[66][67] At the same time the Raspberry Pi Foundation released two additional codecs that can be bought separately, MPEG-2 and Microsoft's VC-1. Also it was announced that the Pi will support CEC, enabling it to be controlled with the television's remote control.[68]
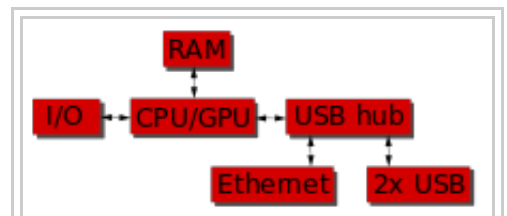
On 5 September 2012, a revision 2.0 board was announced, with a number of minor corrections and improvements.[69]

On 15 October, 2012, the Raspberry PI foundation announced that all new Raspberry PI model B's would be fitted with 512MB RAM chips instead of 256MB chips [13]

Specifications
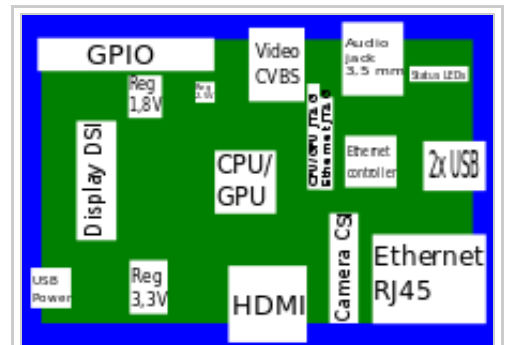
Location on the PCB of connectors and major ICs

Block diagram of the Model-B; in a Model-A the lowest two blocks and the rightmost block are missing (note that these three blocks are in a chip that actually contains a three-port USB hub, with a USB Ethernet adapter connected to one of its ports). In the Model-A the USB port is connected directly to the SoC.

	Model A	**Model B**
Target price:[7]	US$ 25	US$ 35[70]
SoC:[7]	Broadcom BCM2835 (CPU, GPU, DSP, SDRAM, and single USB port)[3]	
CPU:	700 MHz ARM1176JZF-S core (ARM11 family)[3]	
GPU:	Broadcom VideoCore IV,[71] OpenGL ES 2.0, MPEG-2 and VC-1 (with license[68]), 1080p30 h.264/MPEG-4 AVC high-profile decoder and encoder[3]	
Memory (SDRAM):	256 MB (shared with GPU)	512 MB (shared with GPU) as of October 15, 2012
USB 2.0 ports:[14]	1	2 (via integrated USB hub)[64]
Video outputs:[7]	Composite RCA (PAL and NTSC), HDMI (rev 1.3 & 1.4),[72] raw LCD Panels via DSI[73][74] 14 HDMI resolutions from 640×350 to 1920×1200 plus various PAL and NTSC standards.[75]	
Audio outputs:[7]	3.5 mm jack, HDMI	
Onboard storage:[14]	SD / MMC / SDIO card slot	
Onboard network:[7][14]	None	10/100 Ethernet (RJ45) via USB hub[64]
Low-level peripherals:	8 × GPIO, UART, I²C bus, SPI bus with two chip selects, +3.3 V, +5 V, ground[71][76]	
Power ratings:	300 mA (1.5 W)[77]	700 mA (3.5 W)
Power source:[7]	5 volt via MicroUSB or GPIO header	
Size:	85.60 mm × 53.98 mm (3.370 in × 2.125 in)[78]	
Weight:	45 g (1.6 oz)[79]	
Planned operating systems:	Debian GNU/Linux, Fedora, Arch Linux ARM,[2] RISC OS[28], FreeBSD	

Notes

1. **Model A** and **Model B** are cultural references[80] to the original models of the British educational BBC Micro computer, developed by Acorn Computers, who originally developed the ARM processors (the architecture of the Raspberry Pi) and operating system RISC OS, which will also be able to be run on the Raspberry Pi (version 5.17).[28]
2. On the older beta model B boards, 128 MB was allocated by default to the GPU, leaving 128 MB for the CPU.[81] On the first 256 MB release model B (and Model A), three different splits were

possible. The default split was 192 MB (CPU RAM), which should be sufficient for standalone 1080p video decoding, or for simple 3D, but probably not for both together. 224 MB was for Linux only, with just a 1080p framebuffer, and was likely to fail for any video or 3D. 128 MB was for heavy 3D, possibly also with video decoding (e.g. XBMC).[82] Comparatively the Nokia 701 uses 128 MB for the Broadcom VideoCore IV.[83] For the new model B with 512MB RAM initially there were new standard memory split files released(arm256_start.elf, arm384_start.elf, arm496_start.elf) for 256MB, 384MB and 496MB CPU RAM (and 256MB, 128MB and 16MB video RAM). But a week or so later the RPF released a new version of start.elf that could read a new entry in config.txt (gpu_mem=xx) and could dynamically assign an amount of RAM (from 16 to 256MB in 8MB steps) to the GPU, so the older method of memory splits became obsolete, and a single start.elf worked the same for 256 and 512 MB PI's. [84]

3. Level 2 Cache is 128 kB, used primarily by the GPU, not the CPU.

4. The ARM11 is based on version 6 of the ARM architecture, which due to its age is no longer supported by several popular versions of Linux, including Ubuntu.

5. The Raspberry Pi (model B) also contains a 15-pin MIPI camera interface (CSI) connector, which at the moment is unsupported, but the foundation is planning to release a camera module for it, sometime in the near future.[85][86]

6. Support for raw LCD panels is available in hardware through the available DSI connector from the Mobile Industry Processor Interface (MIPI®) Alliance.[73] Software support is being planned.

7. Supported digital video resolutions are: 640 × 350 EGA; 640 × 480 VGA; 800 × 600 SVGA; 1024 × 768 XGA; 1280×720 720p HDTV; 1280 × 768 WXGA Variant; 1280 × 800 WXGA Variant; 1280 × 1024 SXGA; 1366 × 768 WXGA Variant; 1400 × 1050 SXGA+; 1600 × 1200 UXGA; 1680 × 1050 WXGA+; 1920 × 1080 1080p HDTV; 1920 × 1200 WUXGA.[75] Also to be supported are the generation of 576i and 480i composite video signals for PAL-BGHID, PAL-M, PAL-N, NTSC and NTSC-J[87]

8. Originally the on-board USB ports were designed for USB devices using one "unit load" (100 mA) of current. Devices using more than 100 mA were incompatible with the Raspberry Pi, and for them a self-powered USB hub was required. However, due to user feedback, the RPF, at the end of August 2012, decided to remove the USB polyfuses which largely caused this behaviour. However, the maximum current that can be delivered to a USB port on these modified boards is still limited by the capabilities of the power supply used, and the 1.1 A main polyfuse.[88]

9. Newer versions of the firmware contain the option to choose between five overclock ("turbo") presets that when turned on try to get the most performance out of the SoC without impairing the lifetime of the Pi. This is done by monitoring the core temperature of the chip, and the CPU load, and dynamically adjusting clock speeds and the core voltage. So when there is a low demand on the CPU, or it is getting too hot, the performance is throttled down, but if the CPU has much to do, and the chip's temperature allows it, performance is temporarily increased, with clock speeds up to 1 GHz, depending on the individual board, and on which of the "turbo" settings is used. The five settings are:
   1. "None"; 700 MHz ARM, 250 MHz core, 400 MHz SDRAM, 0 overvolt,
   2. "Modest"; 800 MHz ARM, 250 MHz core, 400 MHz SDRAM, 0 overvolt,
   3. "Medium" 900 MHz ARM, 250 MHz core, 450 MHz SDRAM, 2 overvolt,
   4. "High"; 950 MHz ARM, 250 MHz core, 450 MHz SDRAM, 6 overvolt,
   5. "Turbo"; 1000 MHz ARM, 500 MHz core, 600 MHz SDRAM, 6 overvolt[4][89]

Software

The Raspberry Pi uses Linux kernel-based operating systems. Raspbian, a Debian-based free operating system optimized for the Raspberry Pi hardware, is the current recommended system, released in July 2012.[90]

The GPU hardware is accessed via a firmware image which is loaded into the GPU at boot time from the SD-card. The firmware image is known as the binary blob, while the associated Linux drivers are closed source.[91] Application software use calls to closed source run-time libraries which in turn calls an open source driver inside the Linux kernel. The API of the kernel driver is specific for these closed libraries. Video applications use OpenMAX, 3D applications use OpenGL ES and 2D applications use OpenVG which both in turn use EGL. OpenMAX and EGL use the open source kernel driver in turn.[92]

On 19 February 2012, the Raspberry Pi Foundation released its first proof of concept SD card image that could be loaded onto an SD card to produce a preliminary operating system. The image was based upon Debian 6.0 (Squeeze), with the LXDE desktop and the Midori browser, plus various programming tools. The image also runs on QEMU allowing the Raspberry Pi to be emulated on various other platforms.[93]

Visual diagram of API connections

On 8 March, 2012 The Raspberry Pi Foundation released Raspberry Pi Fedora Remix, at the time its recommended Linux distribution,[94] which was developed at Seneca College in Canada.[95] The Foundation intends to create an App Store website for people to exchange programs.[96]
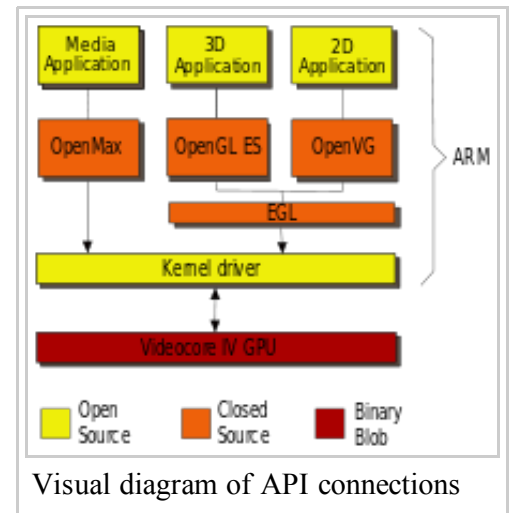
Slackware ARM (formally ARMedslack) version 13.37 and later runs on the Raspberry Pi without modification.[97][98][99] The 128–496 MB of available memory on the Raspberry Pi is twice the minimum requirement of 64 MB needed to run Slackware Linux on an ARM or i386 system.[100] (While Slackware can load and run a GUI, it was designed to be run from the shell.) The Fluxbox window manager running under the X Window System requires an additional 48 MB of RAM.[101]

In addition, work is being done on system-specific light Linux distributions such as IPFire,[102] OpenELEC,[103] Raspbmc[104] and the XBMC open source digital media center.[105]

Trustee Eben Upton publicly approached the RISC OS Open community in July 2011 to enquire about assistance with a potential port.[106] Adrian Lees at Broadcom has since worked on the port,[107][108] with his work being cited in a discussion regarding the graphics drivers.[109]

On October 24, 2012 the Raspberry Pi Foundation announced that "all of the VideoCore driver code which runs on the ARM" had been released as free software under a BSD-style license, making it "the first ARM-based multimedia SoC with fully-functional, vendor-provided (as opposed to partial, reverse engineered) fully open-source drivers", although this claim has not been universally accepted.[110]

Operating systems

This is a list of operating systems running, ported or in the process of being ported to Raspberry Pi.

- **Full OS:**
    - AROS
    - Linux

- Android
  - Android 4.0 (Ice Cream Sandwich)
- Arch Linux ARM
- Debian Squeeze
- Firefox OS
- Gentoo Linux[111]
- Google Chrome OS
- PiBang Linux[112]
- Raspberry Pi Fedora Remix
- Raspbian[113] (Debian Wheezy port with faster floating point support)
- Slackware ARM (formerly ARMedslack)
- QtonPi a cross-platform application framework based Linux distribution based on the Qt framework
- WebOS
  - Open webOS[114]
- Plan 9 from Bell Labs[115][116]
- RISC OS
- Unix
  - FreeBSD[117]
  - NetBSD[118][119]

- **Multi-purpose light distributions:**
  - Moebius (http://moebiuslinux.sourceforge.net/) , a light ARM HF distribution based on Debian. It uses Raspbian repository, but it fits in a 1 GB SD card. It has just minimal services and its memory usage is optimized to keep a small footprint.
  - Squeezed Arm Puppy, a version of Puppy Linux (Puppi) for the ARMv6 (sap6) specifically for the Raspberry Pi.[120]

- **Single-purpose light distributions:**
  - Instant WebKiosk a browser-only operating system
  - IPFire
  - OpenELEC
  - Raspbmc
  - XBMC
  - XBian

Accessories

The Foundation reported on its blog in May 2012 about a prototype camera module they have tested. The prototype uses a 14 megapixel module, with the released version likely to be of lower resolution in order to aid affordability. The release is likely to be in early 2013.[121]

A number of Raspberry Pi specific peripheral devices and cases are available from third-party suppliers.[122] These include the Raspberry Pi Foundation sanctioned Gertboard, which is designed for educational purposes, and expands the Raspberry Pi's GPIO pins to allow interface with and control of LEDs, switches, analog signals, sensors and other devices. It also includes an optional Arduino compatible controller to interface with the Pi.[123]

Community

The Raspberry Pi community was described by Jamie Ayre of FLOSS software company AdaCore as one of the most exciting parts of the project.[54] Community blogger Russell Davis said that the community strength allows the Foundation to concentrate on documentation and teaching.[54] The community is developing fanzines around the platform, such as *The MagPi*.[124] A series of community *Raspberry Jam* events have been held across the UK[125] and further afield,[126] led by Alan O'Donohoe,[125][127][128] principal teacher of ICT at Our Lady's High School, Preston,[129][128] and a teacher-led community from RaspberryJam has started building an crowdsourced Scheme of Work.[130]

Reception & Influence

Technology writer Glyn Moody described the project in May 2011 as a "potential BBC Micro 2.0", not by replacing PC compatible machines but by supplementing them.[131] In March 2012 Stephen Pritchard echoed the "BBC Micro successor" sentiment in *ITPRO*.[132] Alex Hope, co-author of the Next Gen report, is hopeful that the computer will engage children with the excitement of programming.[133] Co-author Ian Livingstone suggested that the BBC could be involved in building support for the device, possibly branding it as the "BBC Nano".[96] Chris Williams, writing in The Register sees the inclusion of programming languages such as Kids Ruby, Scratch and BASIC as a "good start" to equip kids with the skills needed in the future – although it remains to be seen how effective their use will be.[80] The Centre for Computing History strongly supports the Raspberry Pi project, feeling that it could "usher in a new era".[39] Before release, the board was showcased by ARM's CEO Warren East at an event in Cambridge outlining Google's ideas to improve UK science and technology education.[134]

Harry Fairhead, however, suggests that more emphasis should be put on improving the educational software available on existing hardware, using tools such as Google App Inventor to return programming to schools, rather than adding new hardware choices.[135] Simon Rockman, writing in a ZDNet blog, was of the opinion that teens will have "better things to do", despite what happened in the 1980s.[136]

Some open source projects criticized the lack of available hardware documentation (the FAQ on the Raspberry Pi website states that Broadcom does not release a full datasheet for the BCM2835), which would have made porting other operating systems to the Raspberry Pi easier.[137][138]

In October 2012 the Raspberry Pi won T3's "Innovation of the Year" award,[139] and futurist Mark Pesce cited a (borrowed) Raspberry Pi as the inspiration for his ambient device project MooresCloud.[140] In October 2012 the BCS reacted to the announcement of enhanced specifications by stating, "it's definitely something we'll want to sink our teeth into."[141]

Use

As of January 2012, inquiries about the board in the United Kingdom have been received from schools in both the state and independent sectors, with around five times as much interest from the latter. It is hoped that businesses will sponsor purchases for less advantaged schools.[22] The CEO of Premier Farnell said that the government of a country in the Middle East has expressed interest in providing a board to every schoolgirl, in order to enhance their employment prospects.[142][143]

See also

- VIA APC – Android-based PC system from VIA
- Arduino – open-source single-board microcontroller
- BASIC Stamp – microcontroller programmed in BASIC
- BeagleBoard – ARM-based single board computer
- BBC Micro – historic series of microcomputers that inspired the Raspberry Pi
- List of single-board computers

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preloaded SD cards too. ... We'll be using Fedora as our recommended distribution. It's straightforward to replace the root partition on the SD card with another ARM Linux distribution if you want to use something else. The OS is stored on the SD card."

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External links

- Raspberry Pi Foundation official website and forums (http://www.raspberrypi.org)
- Raspberry Pi Wiki, supported by the RPF (http://elinux.org/RaspberryPiBoard)
- Raspberry Pi.SE unofficial forum (http://raspberrypi.stackexchange.com)
- Raspberry Pi official (UK) distributor (Farnell) (http://cpc.farnell.com/)
- Raspberry Pi alternate official distributor (RS components) (http://uk.rs-online.com/web/generalDisplay.html?id=raspberrypi)
- Raspberry Pi technical support, Documents (http://www.element14.com/community/groups/raspberry-pi?view=documents) (Farnell)
- Broadcom BCM2835 – Embedded Multimedia Applications Processor (http://www.broadcom.com/products/BCM2835)
- *Raspberry Pi gpio pinout* (http://www.panu.it/raspberry)
- *Steps to make Raspberry Pi Supercomputer* (http://www.southampton.ac.uk/~sjc/raspberrypi/pi_supercomputer_southampton_web.pdf)

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