Single Board Computer
RaspberryPi

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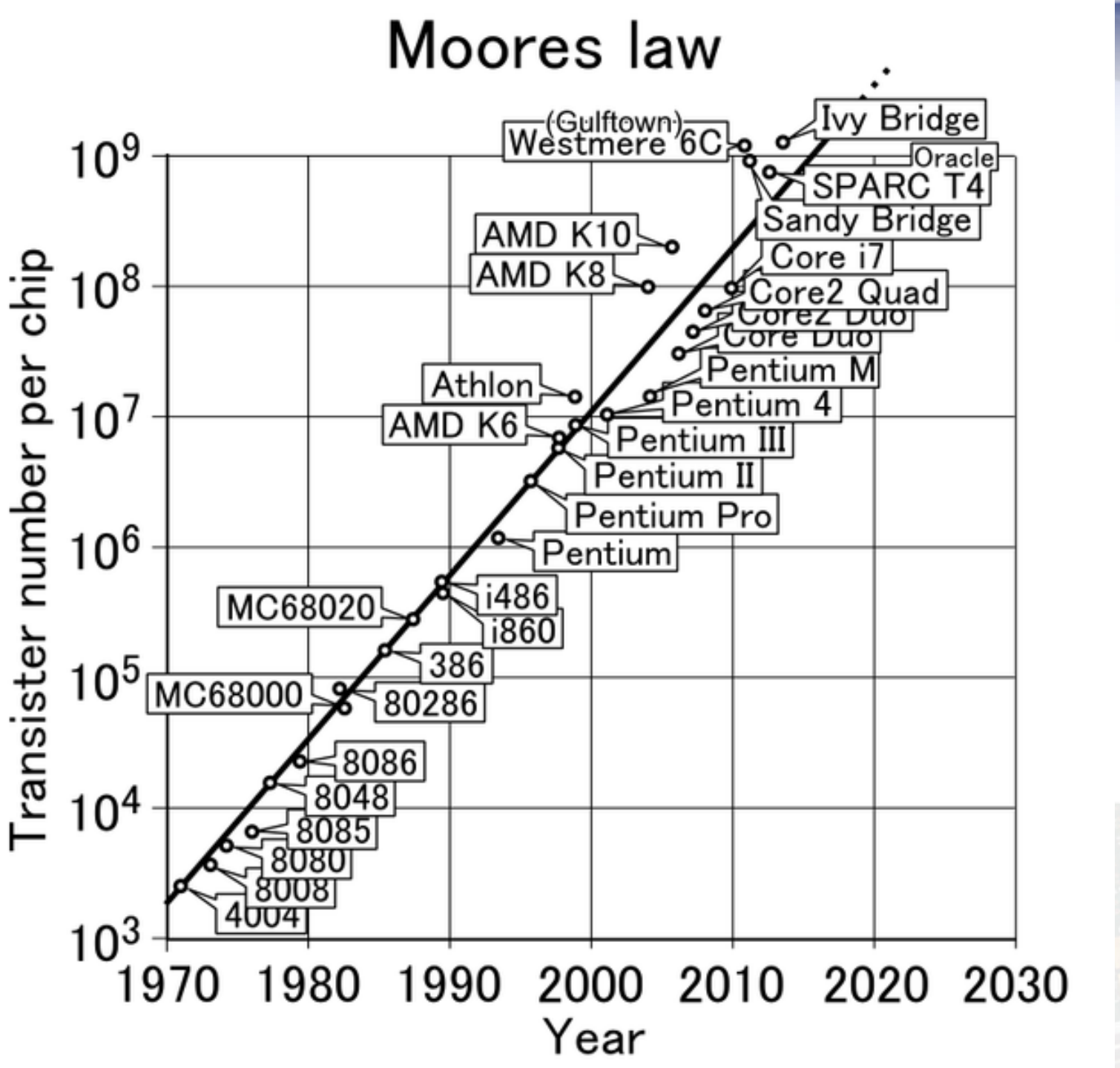
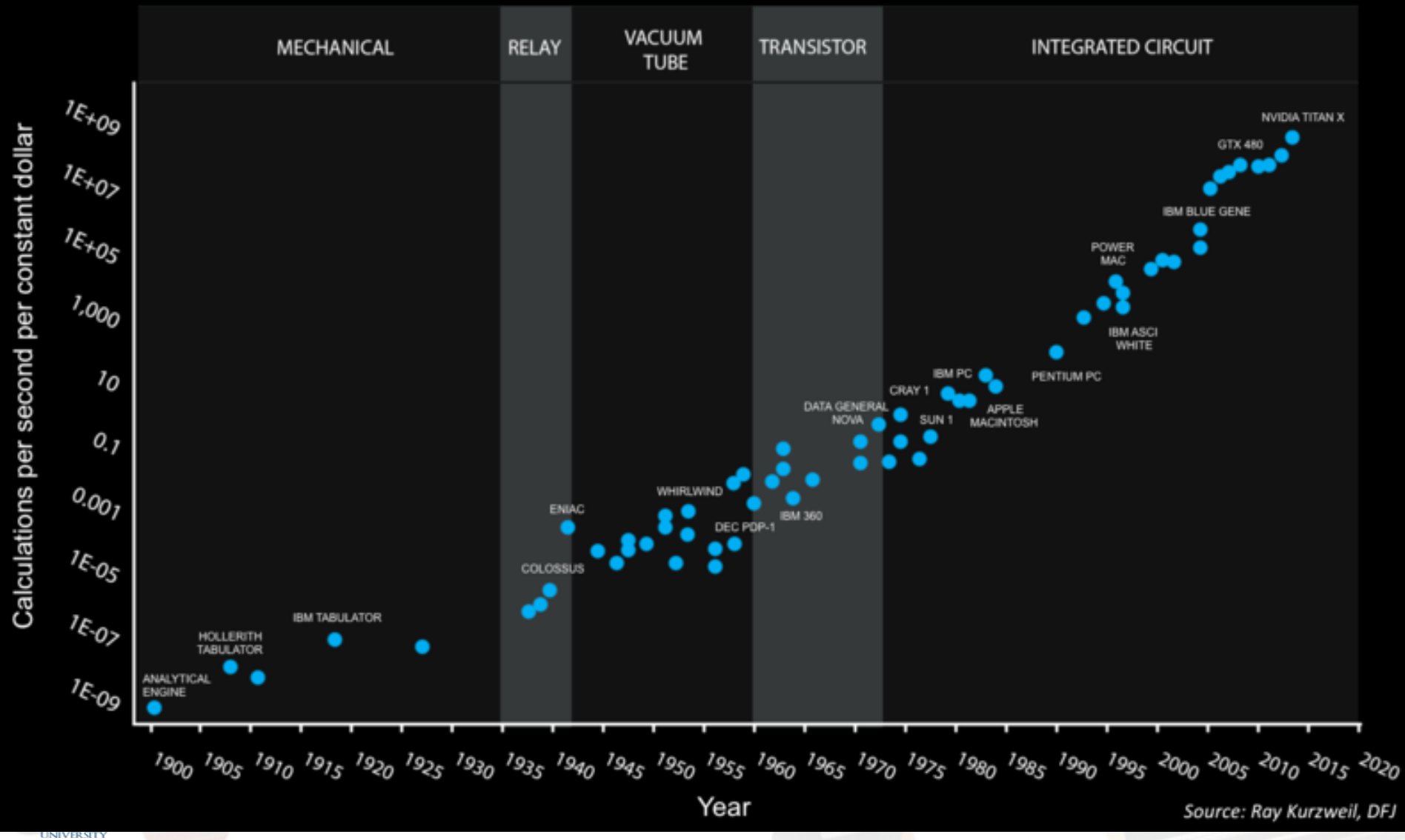

Moores law
Transister number per chip
Year
10^3
10^4
10^5
10^6
10^7
10^8
10^9
1970
1980
1990
2000
2010
2020
2030
4004
8008
8080
8085
8048
8086
80286
386
i860
i486
Pentium
Pentium Pro
Pentium II
Pentium III
Pentium 4
Pentium M
Core Duo
Core2 Duo
Core2 Quad
Core i7
Sandy Bridge
SPARC T4
Oracle
Ivy Bridge
(Gulftown)
Westmere 6C
AMD K10
AMD K8
Athlon
AMD K6
MC68020
MC68000

120 Years of Moore's Law



System Trends

ISA: Instruction Set Architecture

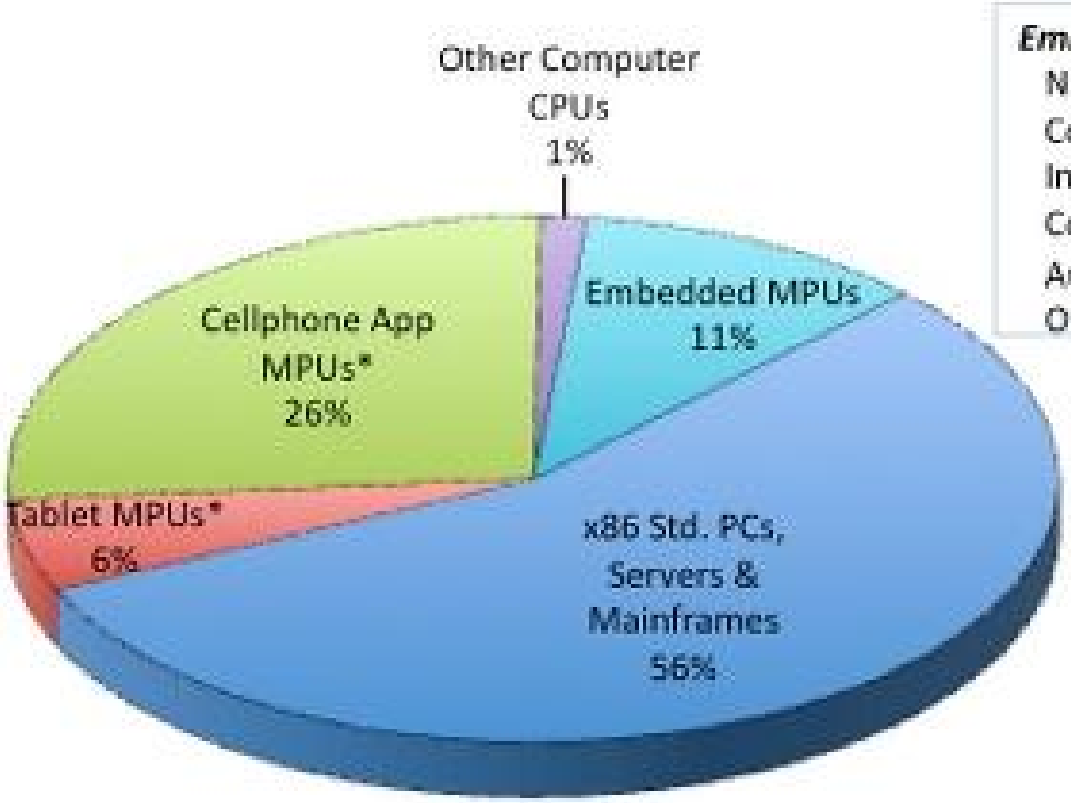
- High-Performance x86 and ARM
- Industry-Leading & Most Efficient GPUs[1,2]
- Scalable Designs
- Memory Innovation
- Open Approach

The Twilight of Moore's Law: Economics

130nm	90nm	65nm/55nm	45/40nm	32/28nm	22/20nm
Altis Semiconductor	Dongbu Hitek	Freescale	Fujitsu	Globalfoundries	Globalfoundries
Dongbu Hitek	Freescale	Fujitsu	Panasonic	Intel	Intel
Freescale	Fujitsu	Globalfoundries	Globalfoundries	Panasonic	Samsung
Fujitsu	Globalfoundries	IBM	IBM	Samsung	ST Microelectronics
Globalfoundries	Grace Semiconductor	Infineon	Intel	ST Microelectronics	TSMC
Grace Semiconductor	IBM	Intel	Renesas (NEC)	TSMC	
IBM	Infineon	Panasonic	Samsung	UMC	
Infineon	Intel	Renesas (NEC)	SMIC		
Intel	Panasonic	Samsung	Sony		
Panasonic	Renesas (NEC)	SMIC	ST Microelectronics		
Renesas (NEC)	Samsung	Sony	Toshiba		
Samsung	Seiko Epson	ST Microelectronics	TSMC		
Seiko Epson	SMIC	Texas Instruments	UMC		
SMIC	Sony	Toshiba			
Sony	ST Microelectronics	TSMC			
ST Microelectronics	Texas Instruments	UMC			
Texas Instruments	Toshiba				
Toshiba	TSMC				
TSMC	UMC				
UMC					

Market volume wall: only the largest volume products will be manufactured with the most advanced technology

Processor Market



Embedded Microprocessors = 11%
Network Processors = 3.1%
Computers & Peripherals =1.5%
Industrial/Medical = 2.5%
Consumer = 1.8%
Automotive = 1.1%
Other = 0.9%

*Includes ARM-based and x86 processors.

Source: IC Insights

Leading MPU Suppliers ($M)

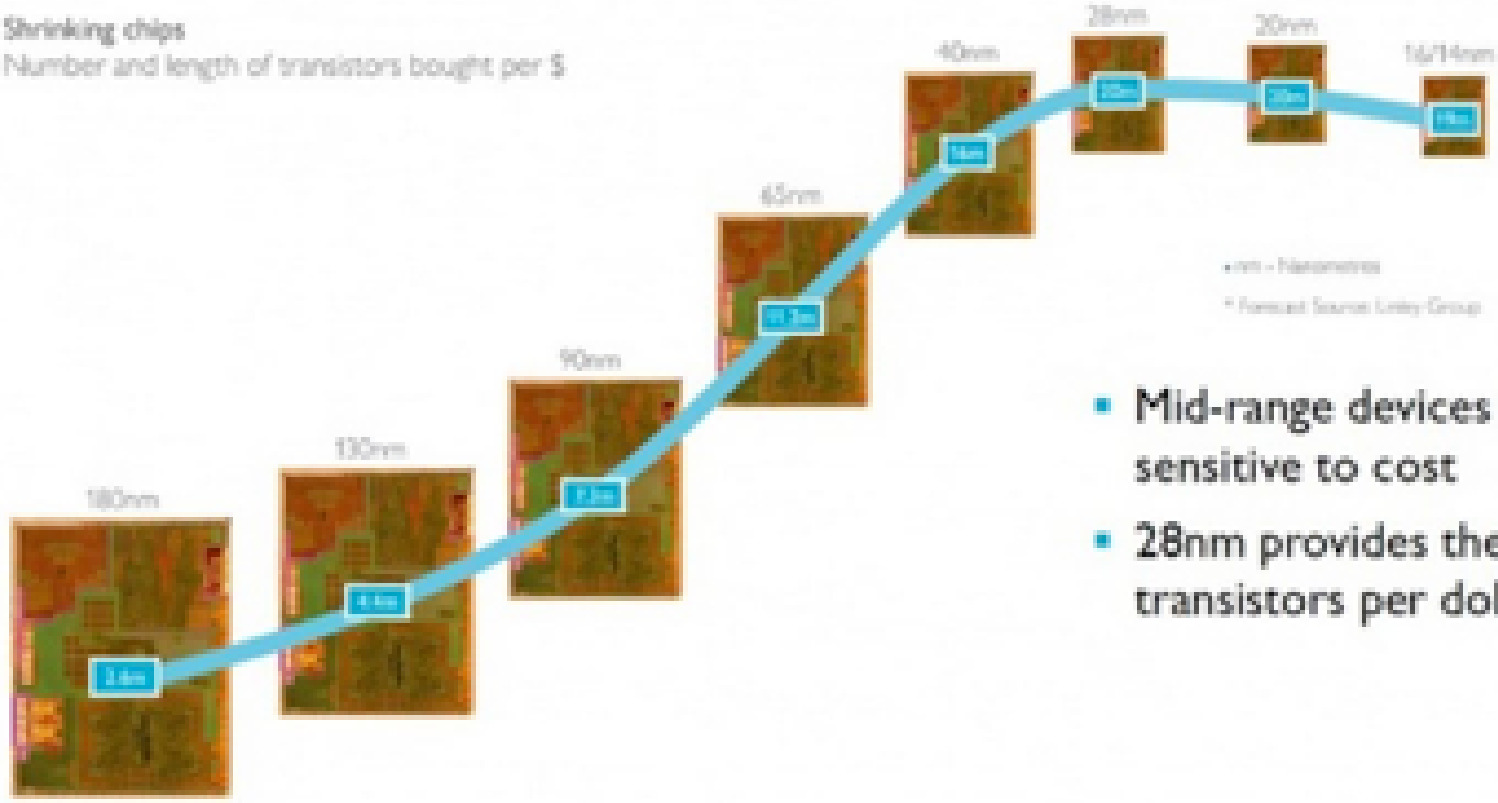
2012 Rank	Company	2011	2012	Percent Change	Percent Marketshare	Main Product Lines
1	Intel	37,435	36,892	-1%	65.3%	x86 PC, server MPUs
2	Qualcomm	4,152	5,322	28%	9.4%	ARM mobile app processors
3	Samsung (+Apple)*	2,614	4,664	78%	8.2%	ARM mobile app processors
4	AMD	4,552	3,605	-21%	6.4%	x86 PC, server MPUs
5	Freescale	1,210	1,070	-12%	1.9%	ARM and embedded MPUs
6	Nvidia	591	764	29%	1.4%	ARM mobile app processors
7	TI	510	565	11%	1.0%	ARM mobile app processors
8	ST-Ericsson**	660	540	-18%	1.0%	ARM mobile app processors
9	Broadcom	295	345	17%	0.6%	ARM mobile app processors
10	MediaTek	280	325	16%	0.6%	ARM mobile app processors

*Includes Apple's custom processors made by Samsung's foundry business.

Source: IC Insights

**Cellphone IC joint venture to be dissovled by STMicroelectronics and Ericsson by 3Q13.

28nm: Optimal Balance of Cost and Power for 2015 Devices



- Mid-range devices are highly sensitive to cost
- 28nm provides the most transistors per dollar

ARM

ARM Cortex Series

Cortex-A

Highest performance
Optimized for rich operating systems

Cortex-R

Fast response
Optimized for high-performance, hard real-time applications

Cortex-M

Smallest/lowest power
Optimized for discrete processing and microcontroller

SecurCore

Tamper resistant
Optimized for security applications

Cortex - A

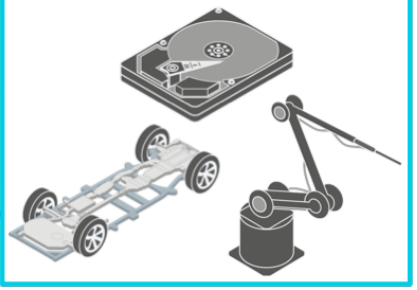
Highest performance

Optimised for rich operating systems

Cortex - R

Fast response

Optimised for high performance, hard real-time applications



Cortex - M

Smallest/lowest power

Optimised for discrete processing and microcontrollers

ARM Cortex-A Series

High performance

Cortex-A73 - 64/32-bit ARMv8-A
2017 Premium Mobile, Consumer

Cortex-A72 - 64/32-bit ARMv8-A
2016 Premium Mobile, Infrastructure & Auto

Cortex-A57 - 64/32-bit ARMv8-A
Proven high-performance

Cortex-A17 - ARMv7-A
High-performance with lower power and smaller area relative to Cortex-A15

Cortex-A15 - ARMv7-A
High-performance with infrastructure feature set

High efficiency

Cortex-A53 - 64/32-bit ARMv8-A
Balanced performance and efficiency

Cortex-A9 - ARMv7-A
Well-established mid-range processor used in many markets

Cortex-A8 - ARMv7-A
First ARMv7-A processor

Ultra-high efficiency

Cortex-A35 - 64/32-bit ARMv8-A
Highest efficiency

Cortex-A32 - 32-bit ARMv8-A
Smallest and lowest power ARMv8-A

Cortex-A7 - ARMv7-A
Most efficient ARMv7-A CPU, higher performance than Cortex-A5

Cortex-A5 - ARMv7-A
Smallest and lowest power ARMv7-A CPU, optimized for single-core

Single Board Computer

A single-board computer (SBC) is a complete computer built on a single circuit board, with microprocessor(s), memory, input/output (I/O) and other features required of a functional computer.

Types of SBC

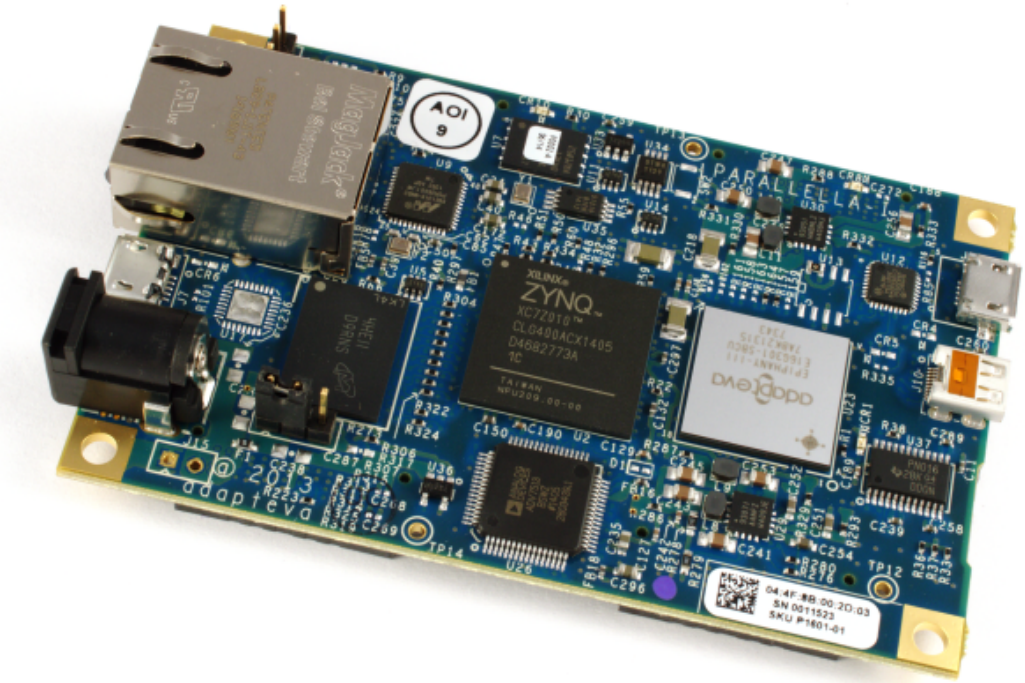
High Performance

Low Power and Low Cost

Parallela

18-core credit card sized computer

- #1 in energy efficiency @ 5W
- 16-core Epiphany RISC SOC
- Zynq SOC (FPGA + ARM A9)
- Gigabit Ethernet
- 1GB SDRAM
- Micro-SD storage
- Up to 48 GPIO pins
- HDMI, USB (optional)
- Open source design files
- Runs Linux



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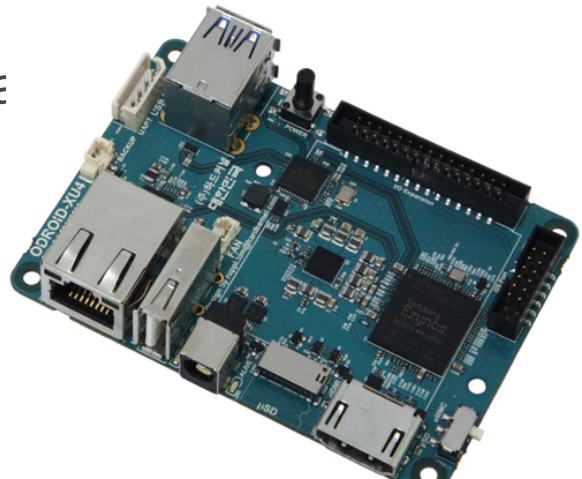
Jetson GPU

GPU: NVIDIA Kepler "GK20a" GPU with 192 SM3.2 CUDA cores (upto 326 GFLOPS)

CPU: NVIDIA "4-Plus-1" 2.32GHz ARM quad-core Cortex-A15 CPU with Cortex-A15 battery-saving shadow-core.

ODROID

* Samsung Exynos5422 Cortex™-A15 2Ghz and Cortex™-A7 Octa core CPUs
* Mali-T628 MP6(OpenGL ES 3.1/2.0/1.1 and OpenCL 1.2 Full profile)
* 2Gbyte LPDDR3 RAM PoP stacked
* eMMC5.0 HS400 Flash Storage
* 2 x USB 3.0 Host, 1 x USB 2.0 Host
* Gigabit Ethernet port
* HDMI 1.4a for display
* Size : 83 x 58 x 22 mm approx.(including cooling fa
* Linux Kernel 4.9 LTS



RaspberyPi

Model Name	Release Date	CPU	RAM	Graphics	USB Ports	Power Requirements
Raspberry Pi 1 Model A	February 2012	700 MHz single-core	256 MB	Broadcom VideoCore IV	1	1.5 W
Raspberry Pi 1 Model B	February 2012	700 MHz single-core	256 MB	Broadcom VideoCore IV	2	3.5 W
Raspberry Pi 1 Model A+	February 2013	700 MHz single-core	256 MB	Broadcom VideoCore IV	1	1.0 W
Raspberry Pi 1 Model A+ Revision 2	N/A	700 MHz single-core	512 MB	Broadcom VideoCore IV		1.0 W
Raspberry Pi 1 Model B revision 2	August 2012	700 MHz single-core	512 MB	Broadcom VideoCore IV		3.5 W
Raspberry Pi 1 Model B+	February 2013	700 MHz single-core	512 MB	Broadcom VideoCore IV	4	3.0 W
Raspberry Pi 2 Model B	February 2015	900 MHz quad-core	1 GB	Broadcom VideoCore IV	4	4.0 W
Raspberry Pi Zero	November 2015	1,000 MHz single-core	512 MB	Broadcom VideoCore IV	1 OTG	0.8 W
Raspberry Pi 3 Model B	February 2016	1,200 MHz quad-core	1 GB	Broadcom VideoCore IV with higher clock speeds	4	4.0 W

RaspberryPi Hardware

SoC: Broadcom BCM2837

- CPU: 4× ARM Cortex-A53, 1.2GHz
- GPU: Broadcom VideoCore IV
- RAM: 1GB LPDDR2 (900 MHz)
- Networking: 10/100 Ethernet, 2.4GHz 802.11n wireless
- Bluetooth: Bluetooth 4.1 Classic, Bluetooth Low Energy
- Storage: microSD
- GPIO: 40-pin header, populated
- Ports: HDMI, 3.5mm analogue audio-video jack, 4× USB 2.0, Ethernet, Camera Serial Interface (CSI), Display Serial Interface (DSI)

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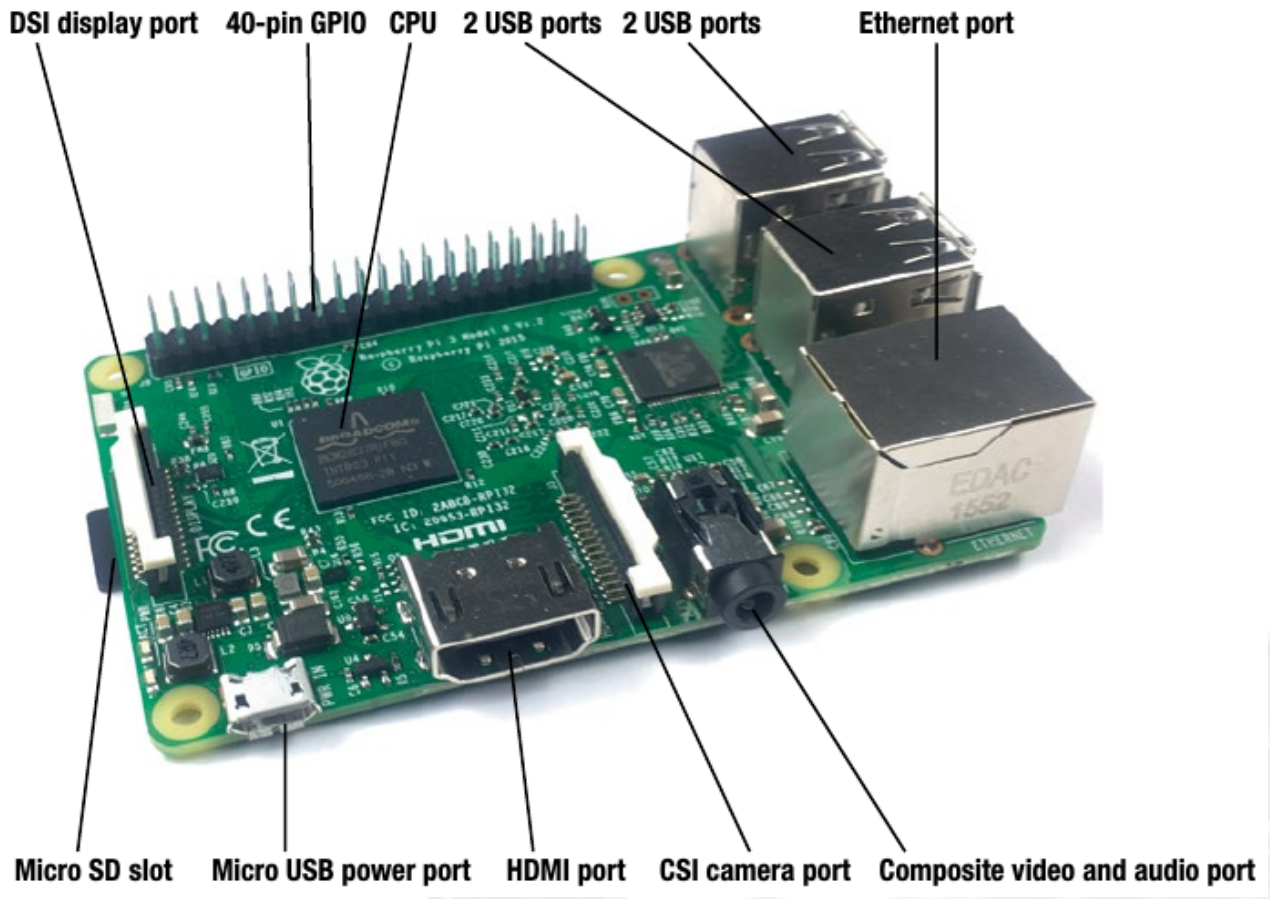
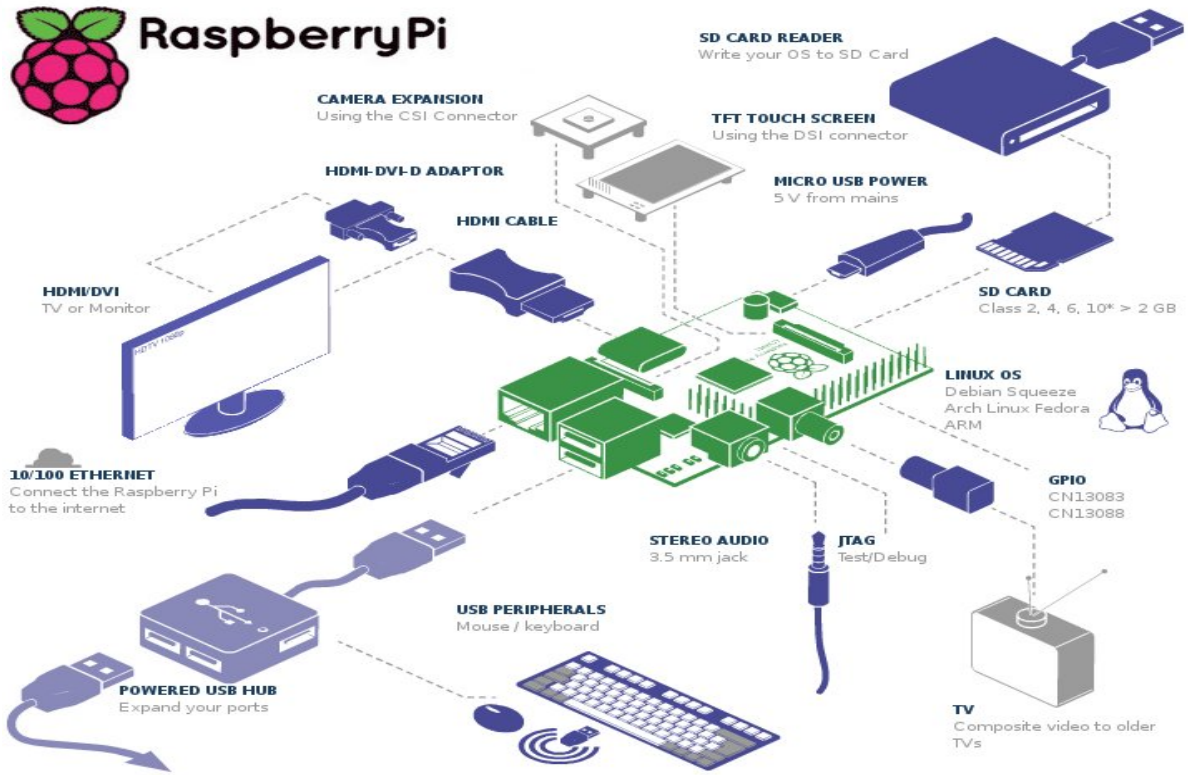
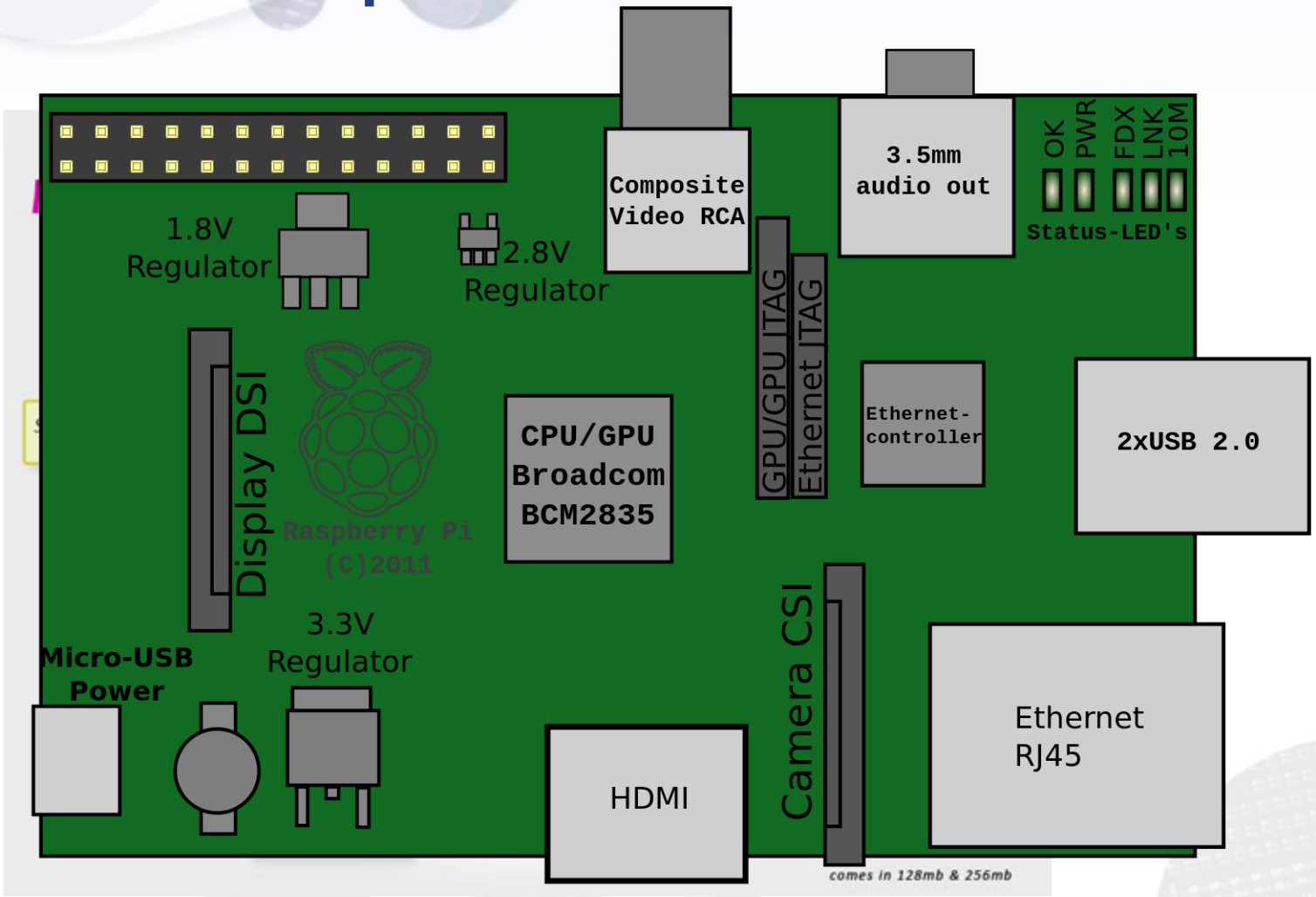


Architecture: RasPi



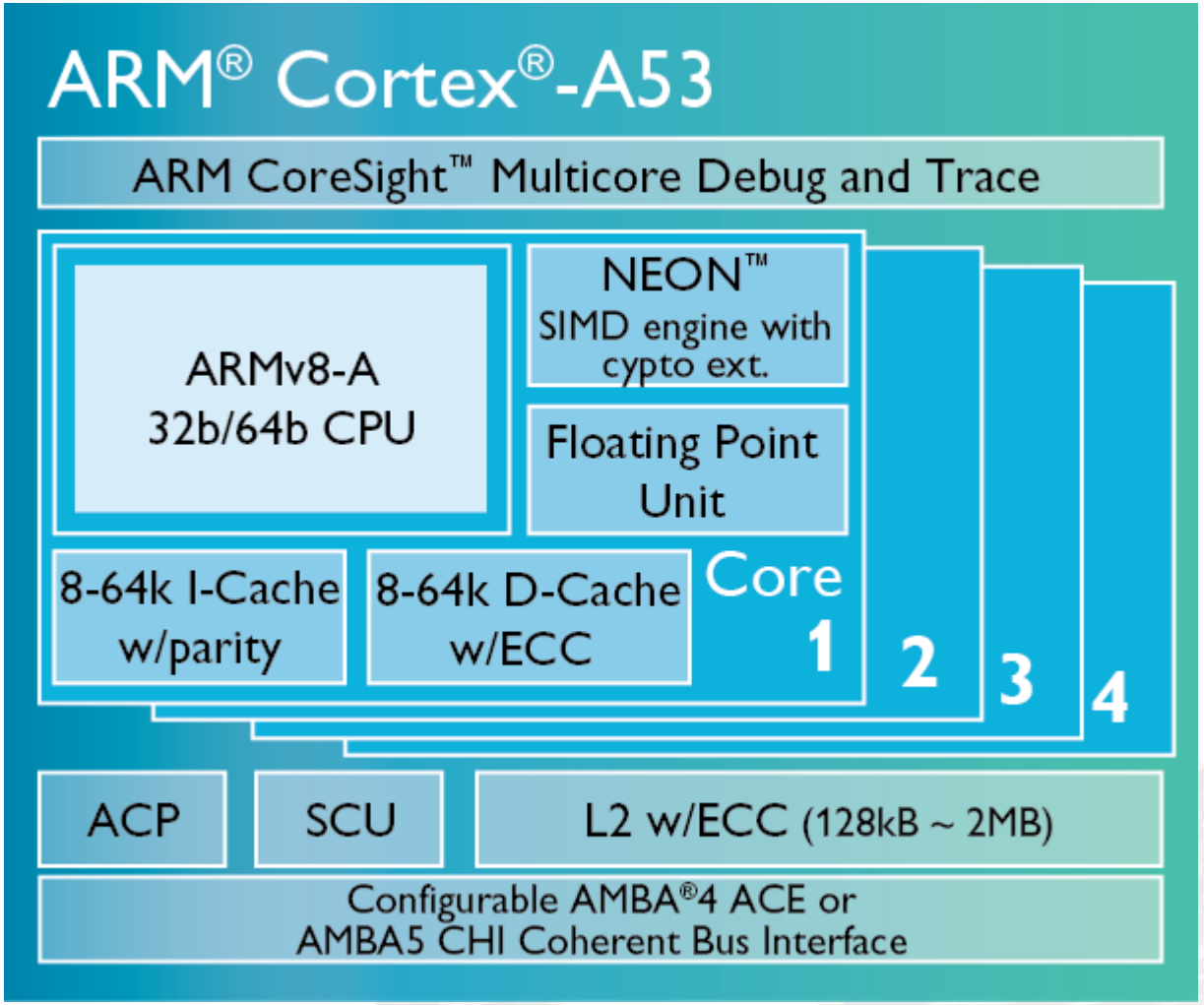
Raspi Ports/Interfaces



Operating System

Because it has an ARM cortex-a processor, it can run the full range of ARM GNU/Linux distributions, including Snappy Ubuntu Core, as well as Microsoft Windows 10.

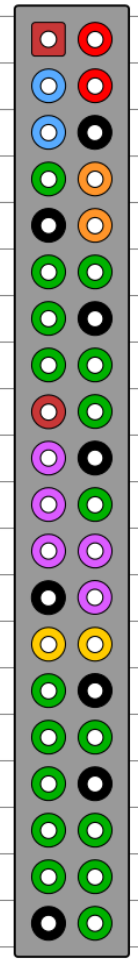
ARM Cortex-A53 Architecture



GPIOs: General Purpose Input Outputs

Raspberry Pi2 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



Rev. 1
26/01/2014

http://www.element14.com

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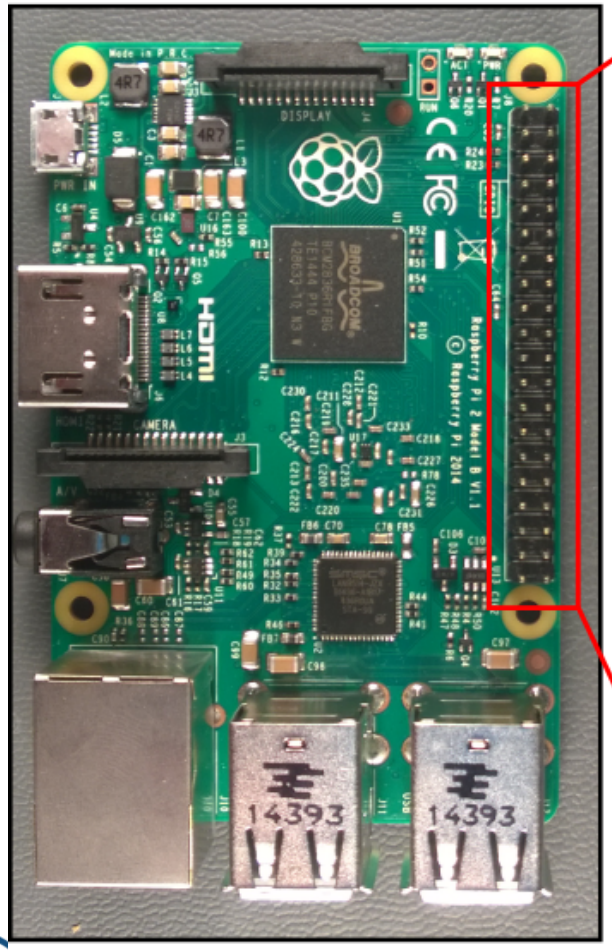

Alternate Function						Alternate Function
	3.3V PWR	1		2	5V PWR	
I2C1 SDA	GPIO 2	3		4	5V PWR	
I2C1 SCL	GPIO 3	5		6	GND	
	GPIO 4	7		8	UART0 TX	
	GND	9		10	UART0 RX	
	GPIO 17	11		12	GPIO 18	
	GPIO 27	13		14	GND	
	GPIO 22	15		16	GPIO 23	
	3.3V PWR	17		18	GPIO 24	
SPI0 MOSI	GPIO 10	19		20	GND	
SPI0 MISO	GPIO 9	21		22	GPIO 25	
SPI0 SCLK	GPIO 11	23		24	GPIO 8	SPI0 CS0
	GND	25		26	GPIO 7	SPI0 CS1
	Reserved	27		28	Reserved	
	GPIO 5	29		30	GND	
	GPIO 6	31		32	GPIO 12	
	GPIO 13	33		34	GND	
SPI1 MISO	GPIO 19	35		36	GPIO 16	SPI1 CS0
	GPIO 26	37		38	GPIO 20	SPI1 MOSI
	GND	39		40	GPIO 21	SPI1 SCLK

Raspi Usage and Applications