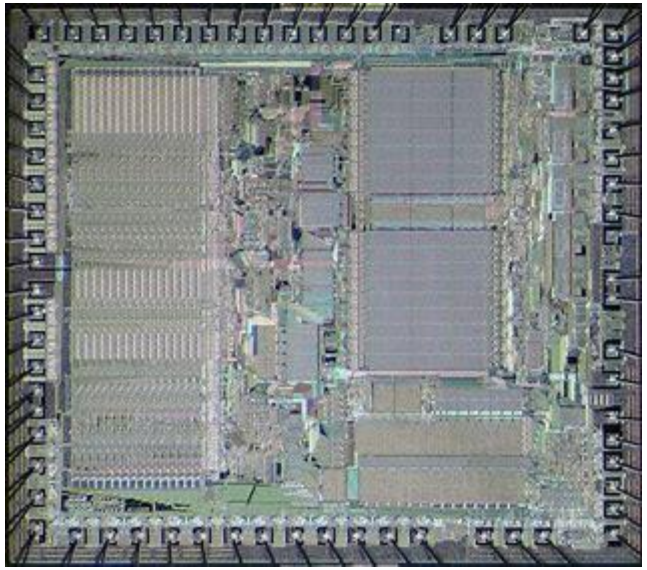
Microprocessor History Lession

MICROPROCESSORS AND MICROCONTROLLERS I



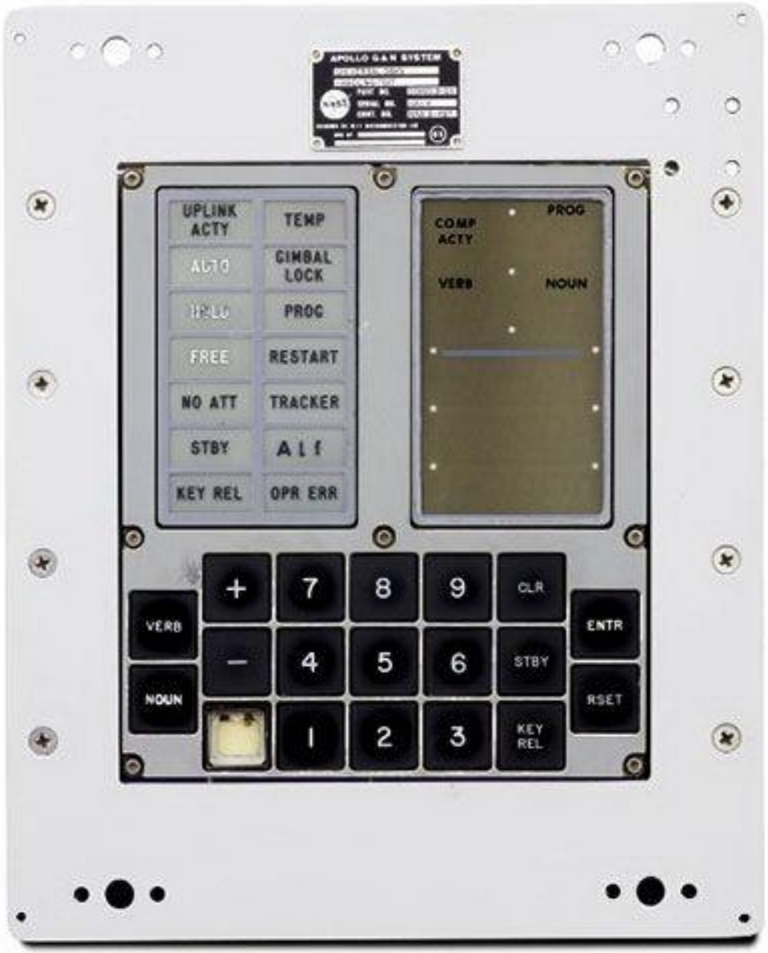
1947

Electronics:

William Shockley, John Bardeen and Walter Brattain build the first practical point-contact transistor at Bell Labs

Apollo Guidance Computer (AGC) makes its debut 1960s

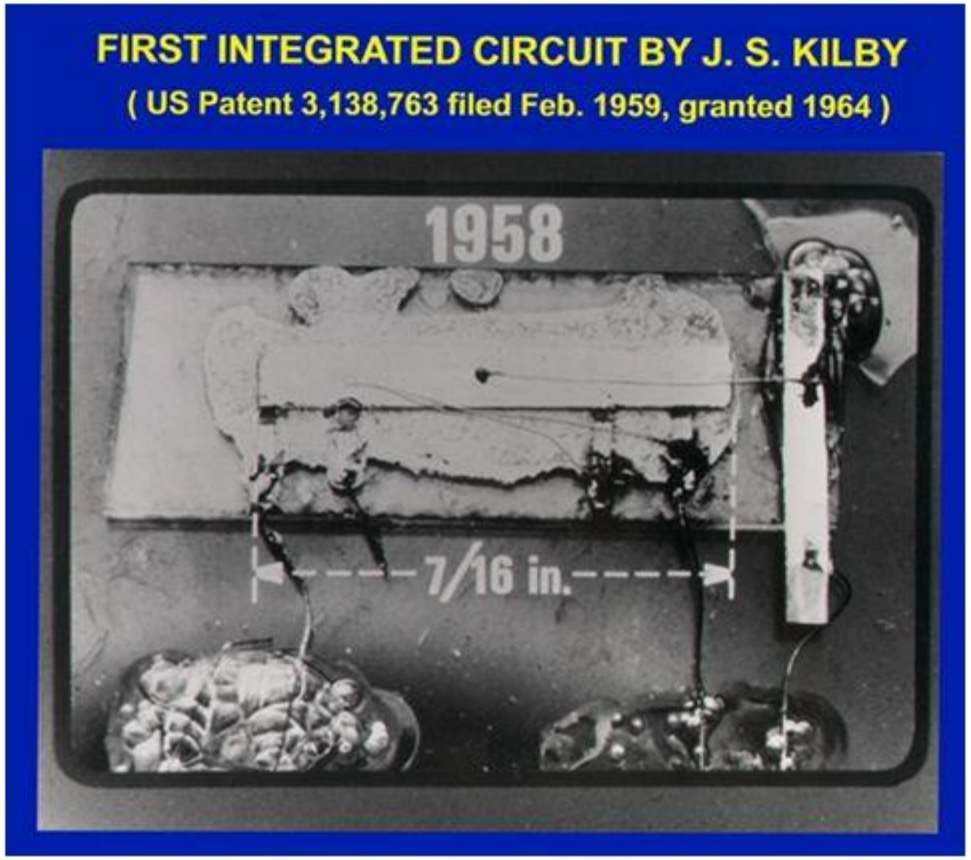
Early Embedded System



Apollo Guidance Computer

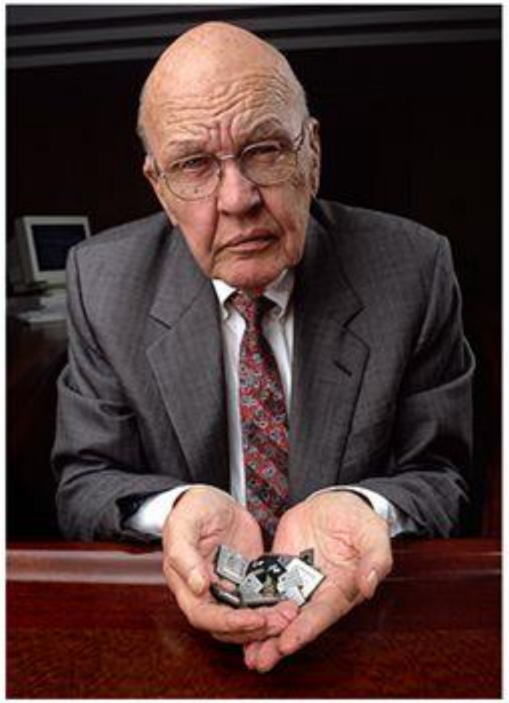
Designed by scientists and engineers at MIT's Instrumentation Laboratory, the Apollo Guidance Computer (AGC) is the culmination of years of work to reduce the size of the Apollo spacecraft computer from the size of seven refrigerators side-by-side to a compact unit weighing only 70 lbs. and taking up a volume of less than 1 cubic foot. The AGC's first flight was on Apollo 7. **A year later, it steered Apollo 11 to the lunar surface.** Astronauts communicated with the computer by punching two-digit codes into the display and keyboard unit (DSKY). The AGC was one of the earliest uses of integrated circuits, and used core memory, as well as read-only magnetic rope memory. The astronauts were responsible for entering more than 10,000 commands into the AGC for each trip between Earth and the Moon.

Integrated Circuit (IC) invented by Kilby from TI



A simple oscillator IC with five integrated components (resistors, capacitors, distributed capacitors and transistors) on Ge substrate.

IC: integrate multiple components on the same chip and to interconnect them to form a circuit.



Jack Kilby, Nobel Prize in Physics in 2000

To read (if interested) "Turning Potential into Realities: The Invention of the Integrated Circuit (Nobel Lecture)"
http://www3.interscience.wiley.com/cgi-bin/fulltext/85010385/PDFSTART

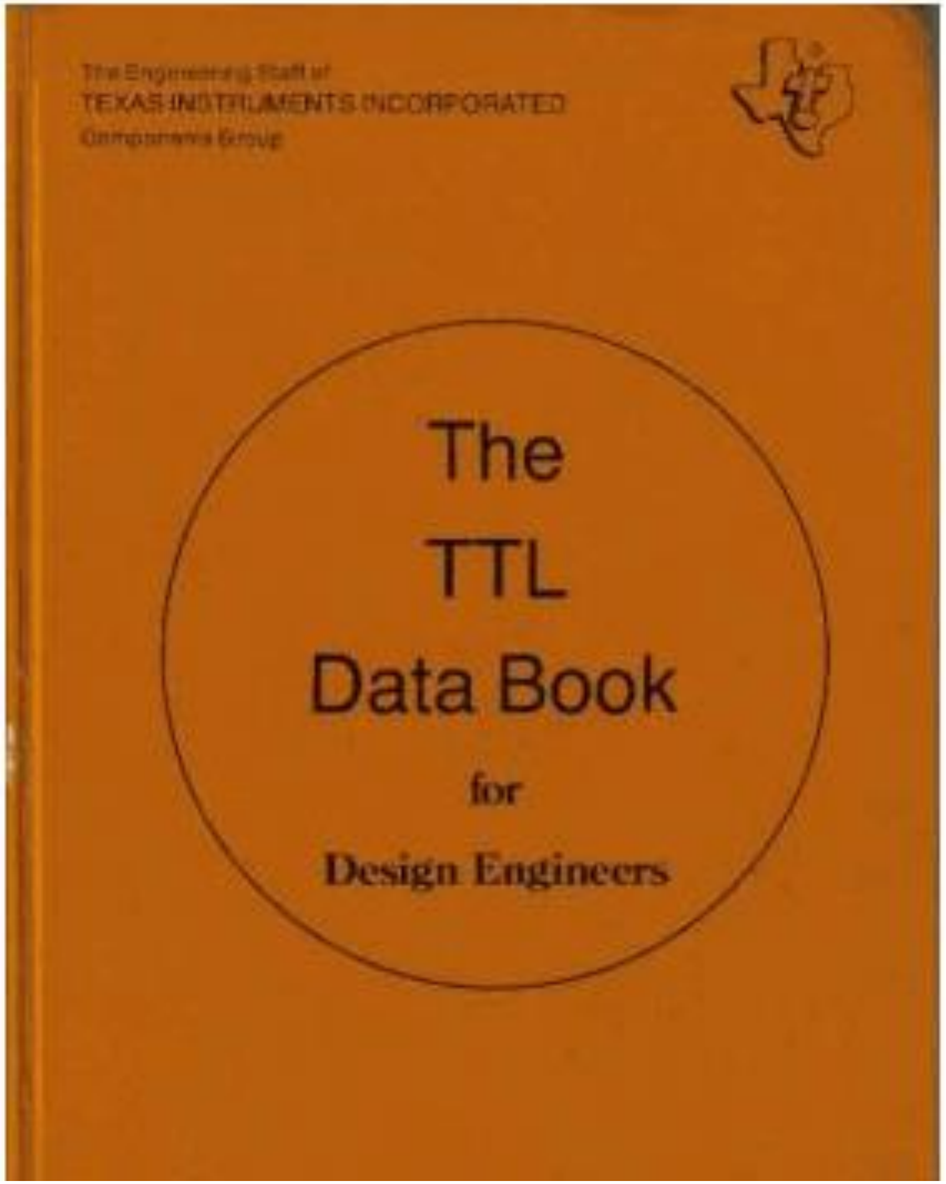
TI: Texas Instrument

✓ There is no consensus on who invented the IC. The American press of the 1960s named four people: Kilby, Lehovec, Noyce and Hoerni; in the 1970s the list was shortened to Kilby and Noyce. Kilby was awarded the 2000 Nobel Prize in Physics "for his part in the invention of the integrated circuit". In the 2000s, historians Leslie Berlin, Bo Lojek and Arjun Saxena reinstated the idea of multiple IC inventors and revised the contribution of Kilby.

1962

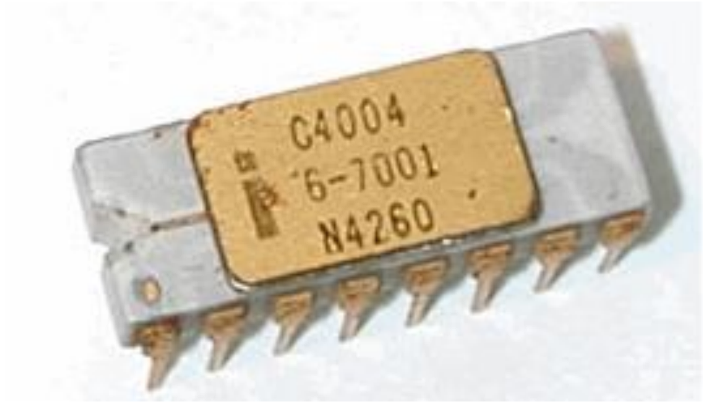
Computer technology:

Texas Instruments introduces the 7400 series of logic ICs.



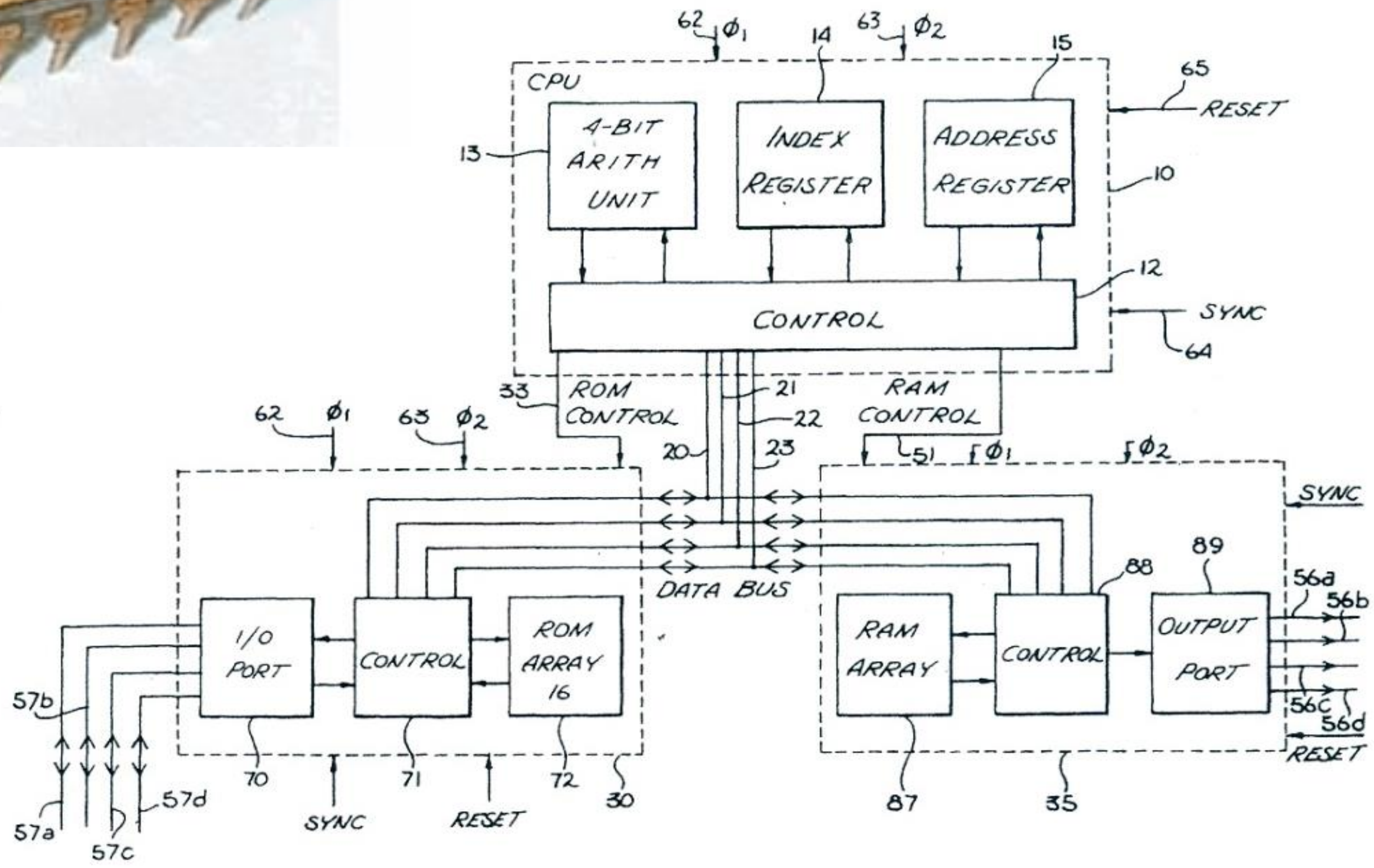
Early Microprocessors and Patents

Note the Architecture on the original Intel Microprocessor



Federico Faggin
Marcian Hoff
Stanley Mazor

SINGLE-CHIP CPU



Wozniak [45] **Jan. 23, 1979**

[54] **MICROCOMPUTER FOR USE WITH VIDEO DISPLAY**

[75] Inventor: **Stephen G. Wozniak**, Cupertino, Calif.

[73] Assignee: **Apple Computer, Inc.**, Cupertino, Calif.

[21] Appl. No.: **786,197**

[22] Filed: **Apr. 11, 1977**

[51] **Int. Cl.**[2] **H04N 9/44**
[52] **U.S. Cl.** **358/17**
[58] **Field of Search** 358/17, 148, 150

[56] **References Cited**

U.S. PATENT DOCUMENTS

3,581,011 5/1971 Ward et al. 358/17

Primary Examiner—Richard Murray

Attorney, Agent, or Firm—Blakely, Sokoloff, Taylor & Zafman

[57] **ABSTRACT**

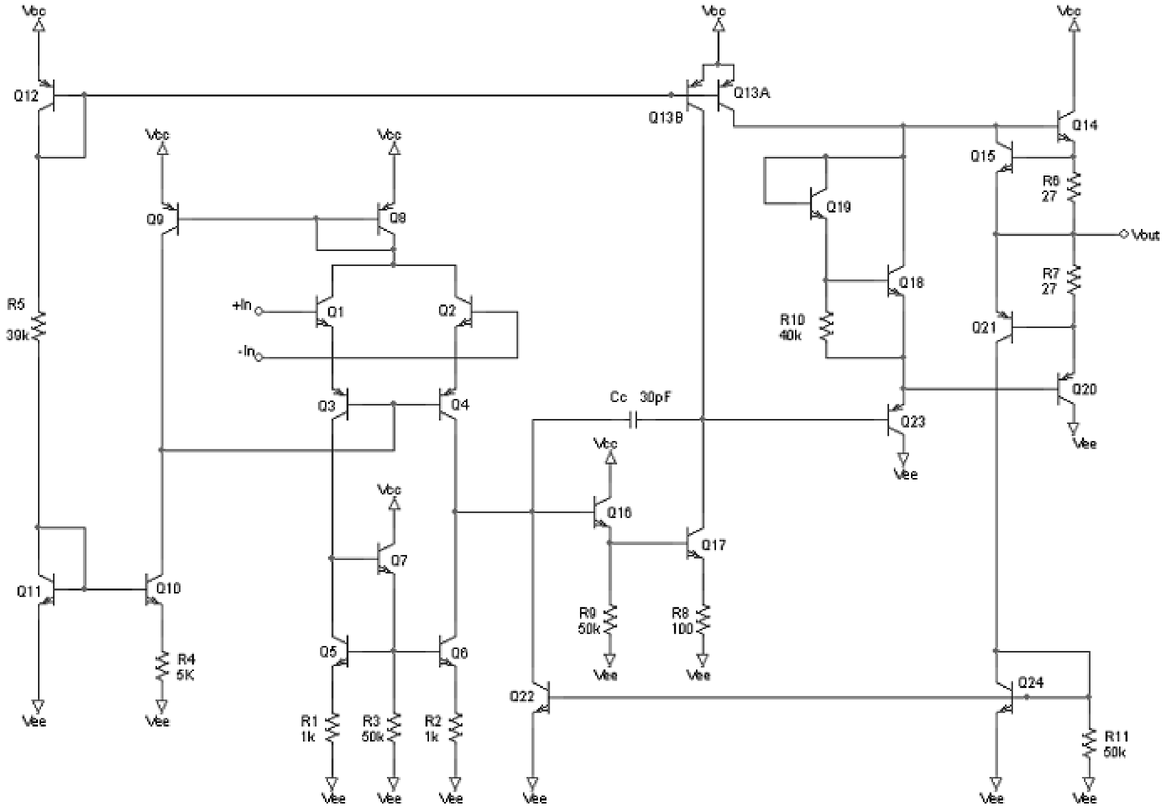
A microcomputer including a video generator and timing means which provides color and high resolution graphics on a standard, raster scanned, cathode ray tube is disclosed. A horizontal synchronization counter is synchronized at an odd-submultiple of the color subcarrier reference frequency. A "delayed" count is employed in the horizontal synchronization counter to compensate for color subcarrier phase reversals between lines for the non-interlaced fields. This permits vertically aligned color graphics without substantially altering the standard horizontal synchronization frequency. Video color signals are generated directly from digital signals by employing a recirculating shift register.

8 Claims, 4 Drawing Figures

1968

Electronics:

Fairchild introduces the 741, the most popular op amp of all time, which was destined to be used in vast numbers of embedded systems.

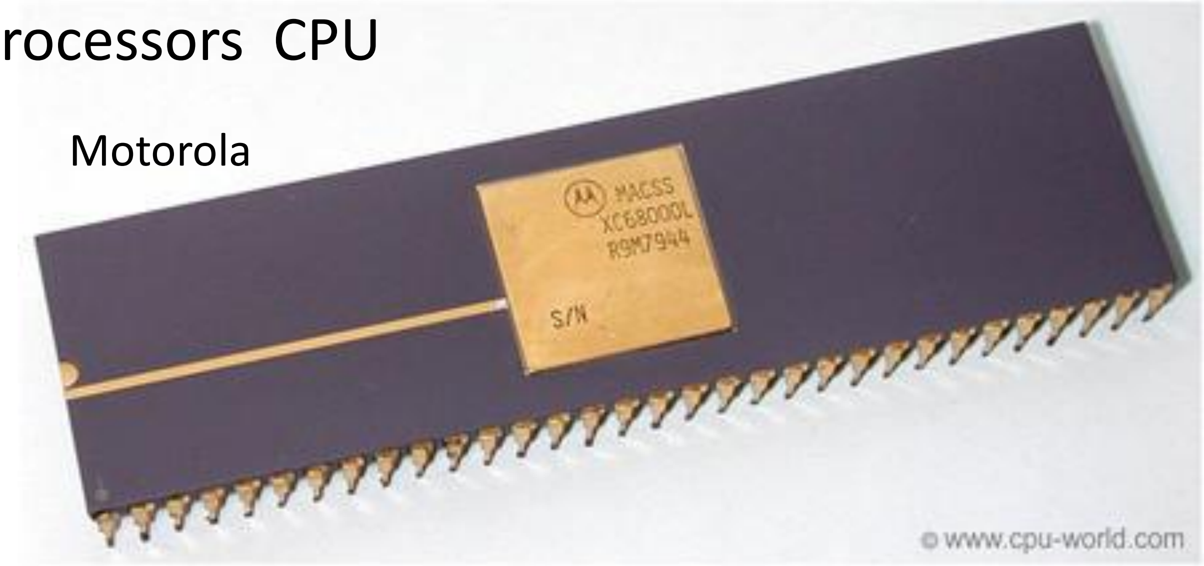


ARCHITECTURES

- Microprocessors vs Microcomputers
- RISC vs CISC
- ARM Architecture

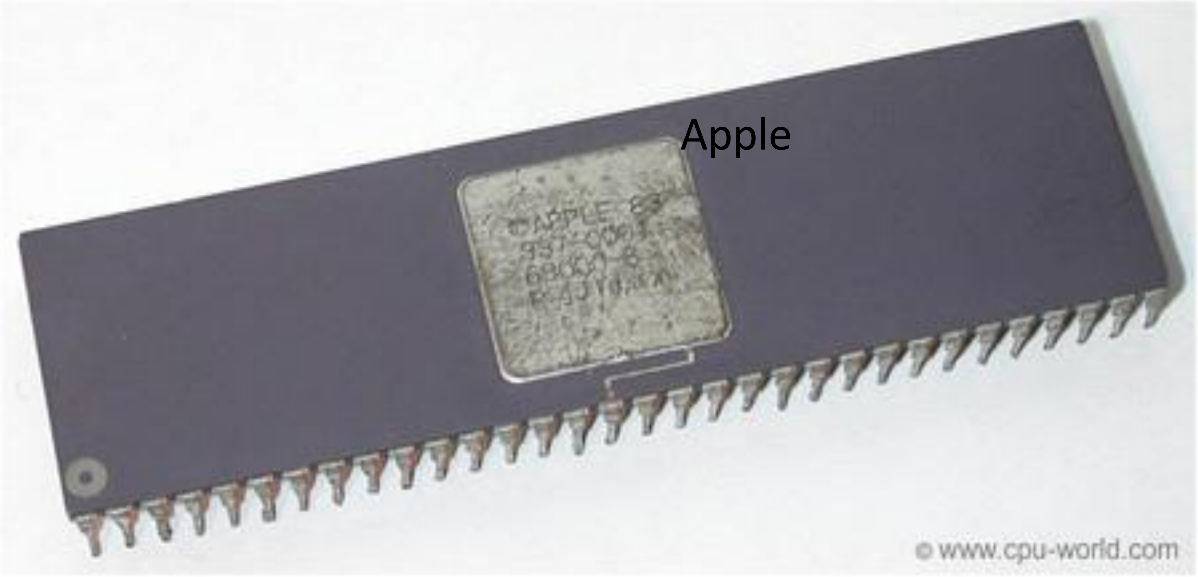
Moving to 16 bit Processors CPU

Motorola



68000 Transistors!

Apple



2004

Motorola, one of the greatest microprocessor companies, exits the business to focus on the growth potential of cell phones.

M68000 as Hardware Device

Block Diagram

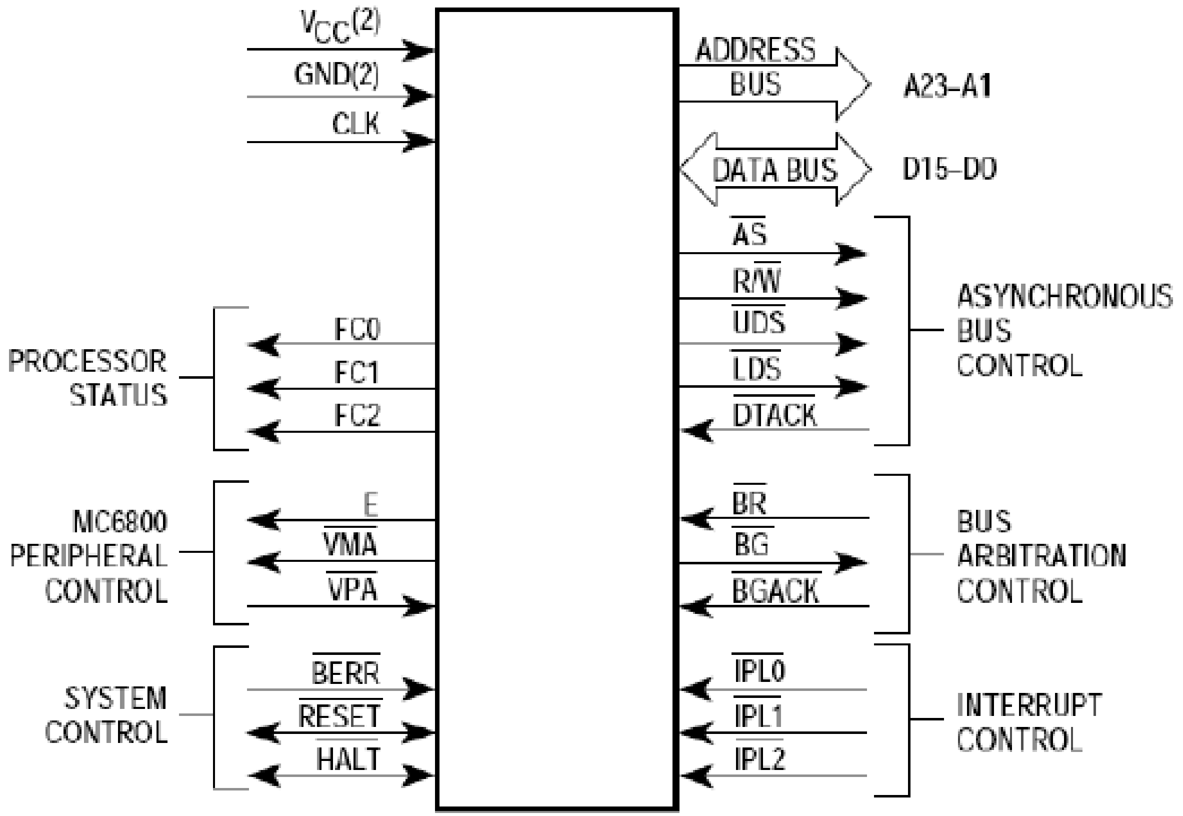


Figure 3-1. Input and Output Signals (MC68000, MC68HC000 and MC68010)

64-Pin DIP Pinouts

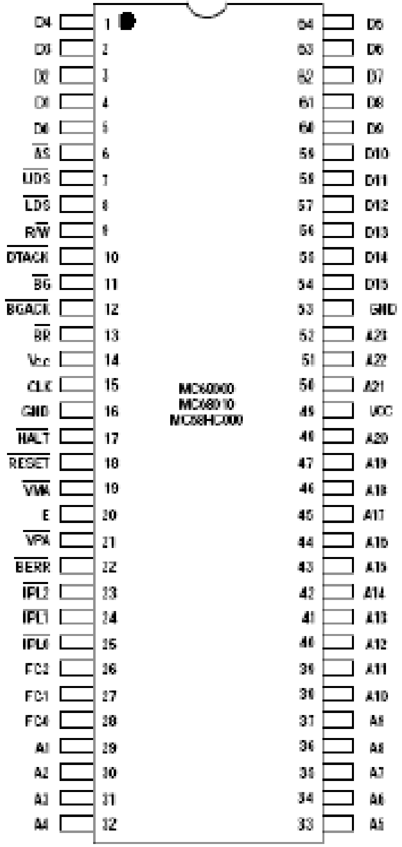
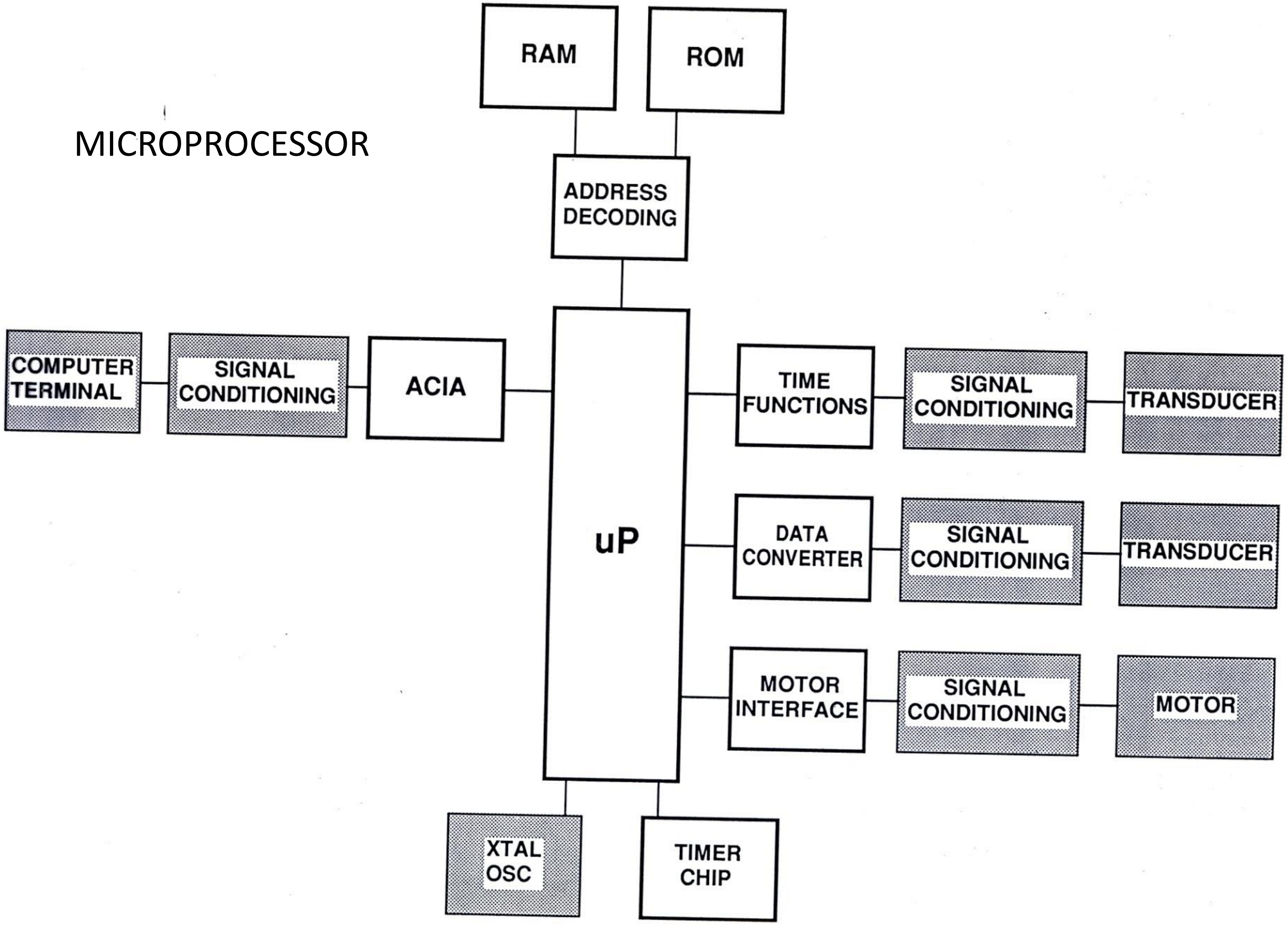


Figure 11-1. 64-Pin Dual In Line

Figures from M68000 Microprocessors User's Manual 9th Ed., © 1993 Motorola Inc.

MICROPROCESSOR



SINGLE BUS EXTERNAL

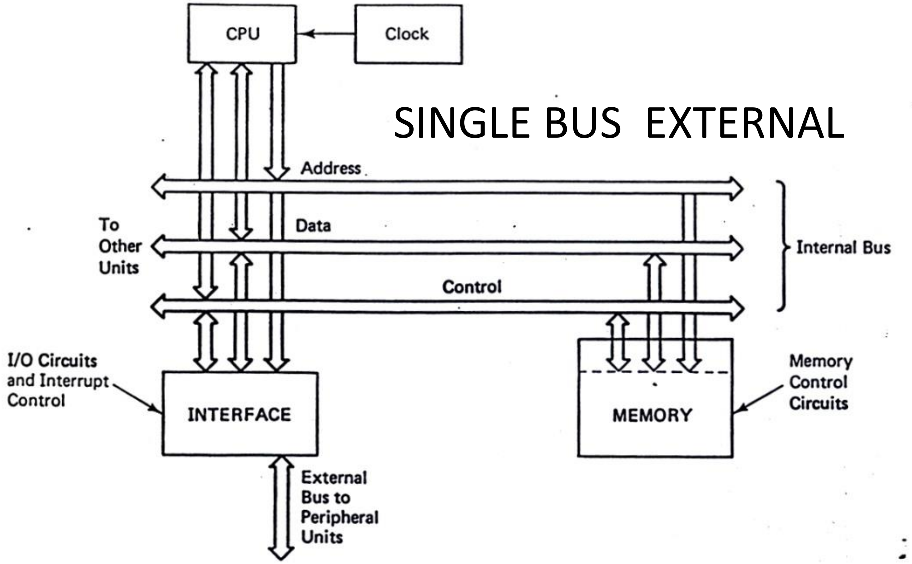


Figure 2.1 Simplified microcomputer organization.

INTERNAL BUS

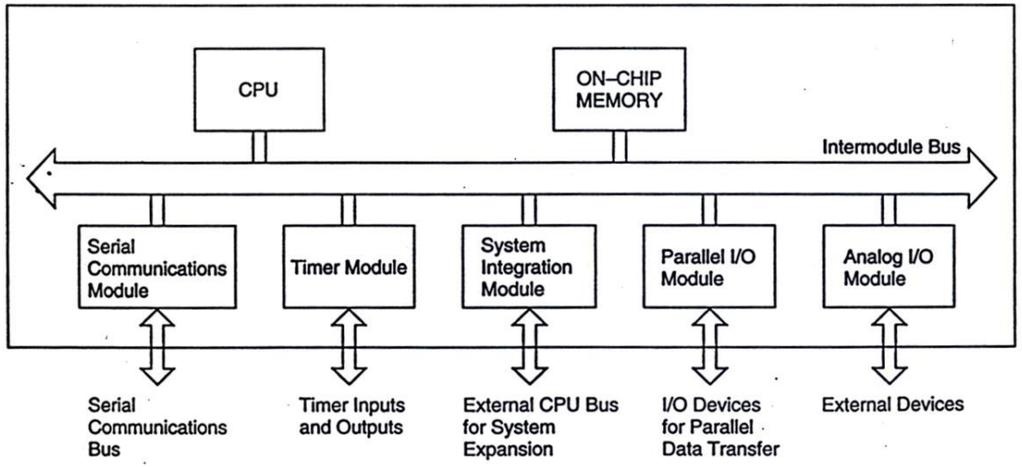


Figure 2.3 Typical microcontroller organization.

CISC	RISC
The original microprocessor ISA	Redesigned ISA that emerged in the early 1980s
Instructions can take several clock cycles	Single-cycle instructions
Hardware-centric design – the ISA does as much as possible using hardware circuitry	Software-centric design – High-level compilers take on most of the burden of coding many software steps from the programmer
More efficient use of RAM than RISC	Heavy use of RAM (can cause bottlenecks if RAM is limited)
Complex and variable length instructions	Simple, standardized instructions
May support microcode (micro-programming where instructions are treated like small programs)	Only one layer of instructions
Large number of instructions	Small number of fixed-length instructions
Compound addressing modes	Limited addressing modes

ARM, originally **Acorn RISC Machine**, later **Advanced RISC Machine**, is a family of reduced instruction set computing (RISC) architectures for computer processors, configured for various environments. British company ARM Holdings develops the architecture and licenses it to other companies, who design their own products that implement one of those architectures—including systems-on-chips (SoC) and systems-on-modules (SoM) that incorporate memory, interfaces, radios, etc. It also designs cores that implement this instruction set and licenses these designs to a number of companies that incorporate those core designs into their own products.

https://en.wikipedia.org/wiki/ARM_architecture

✓

The first **ARM processor** was developed in the **year** 1978 by Cambridge University, and the first **ARM** RISC **processor** was produced by the Acorn Group of Computers in the **year** 1985

1990-1994 Joint Test Action Group (**JTAG**) is the common name for the IEEE 1149.1 **Standard Test Access Port and Boundary-Scan Architecture**. It was initially devised by electronic engineers for testing printed circuit boards using boundary scan and is still widely used for this application.

Today, JTAG is also widely used for IC debug ports. In the embedded processor market, essentially all modern processors implement JTAG when they have enough pins. Embedded systems development relies on debuggers communicating with chips with JTAG to perform operations like single stepping and breakpointing.

BREY

2000, until August 2008.

TABLE 1–2 Many modern Intel and Motorola microprocessors.

Manufacturer	*Part*	*Data Bus Width*	*Memory Size*
Intel	8048	8	2K internal
	8051	8	8K internal
	8085A	8	64K
	8086	16	1M
	8088	8	1M
	8096	16	8K internal
	80186	16	1M
	80188	8	1M
	80251	8	16K internal
	80286	16	16M
	80386EX	16	64M
	80386DX	32	4G
	80386SL	16	32M
	80386SLC	16	32M + 1K cache
	80386SX	16	16M
	80486DX/DX2	32	4G + 8K cache
	80486SX	32	4G + 8K cache
	80486DX4	32	4G + 16K cache
	Pentium	64	4G + 16K cache
	Pentium Overdrive (P24T) (replaces 80486)	32	4G + 16K cache
	Pentium Pro processor	64	64G + 16K L1 cache + 256K L2 cache
	Pentium II	64	64G + 32K L1 cache + 512K L2 cache
	Pentium II Xeon	64	64G + 32K L1 cache + 512K or 1M L2 cache
	Pentium III, Pentium 4	64	64G + 32K L1 cache + 256K L2 cache
Motorola	6800	8	64K
	6805	8	2K
	6809	8	64K
	68000	16	16M
	68008Q	8	1M
	68008D	8	4M
	68010	16	16M
	68020	32	4G
	68030	32	4G + 256 cache
	68040	32	4G + 8K cache
	68050	32	Proposed, but never released
	68060	64	4G + 16K cache
	PowerPC	64	4G + 32K cache

OTHER DESIGN OPTIONS

- Single Board Computers
- System on a Chip (SoC)
- Software flexibility, Hardware deterministic timing!! CPU + FPGA
- Graphical Processing Units
- AI Processing Units

COMPUTER BOARDS FOR THE MASSES!

The Apple iPhone is released 2008

✓

–

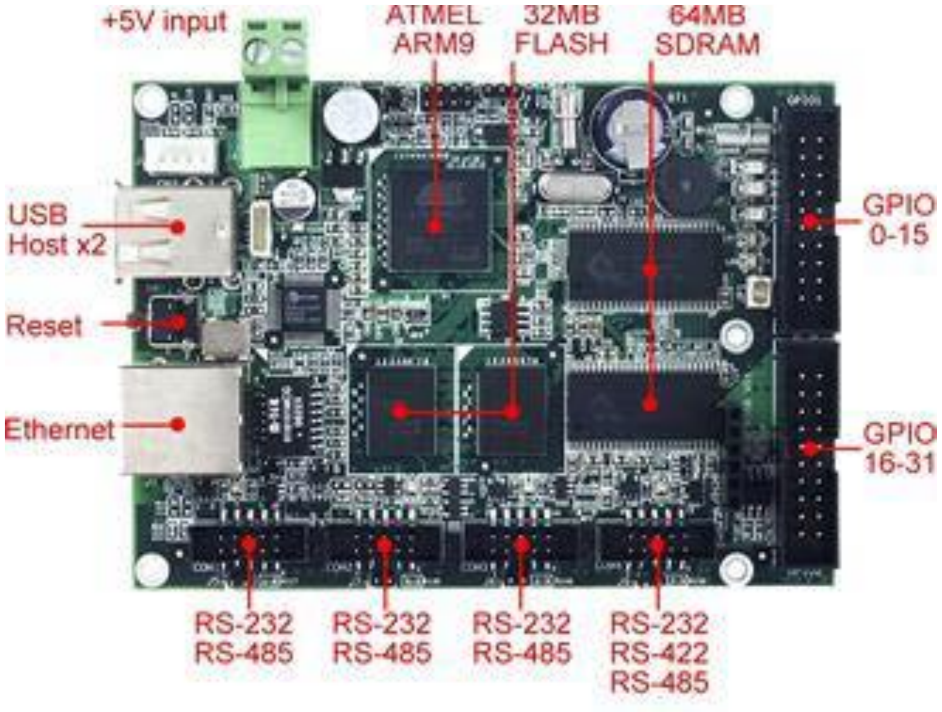
Raspberry Pi, a credit-card-size single board computer, is released as a tool to promote science education 2012

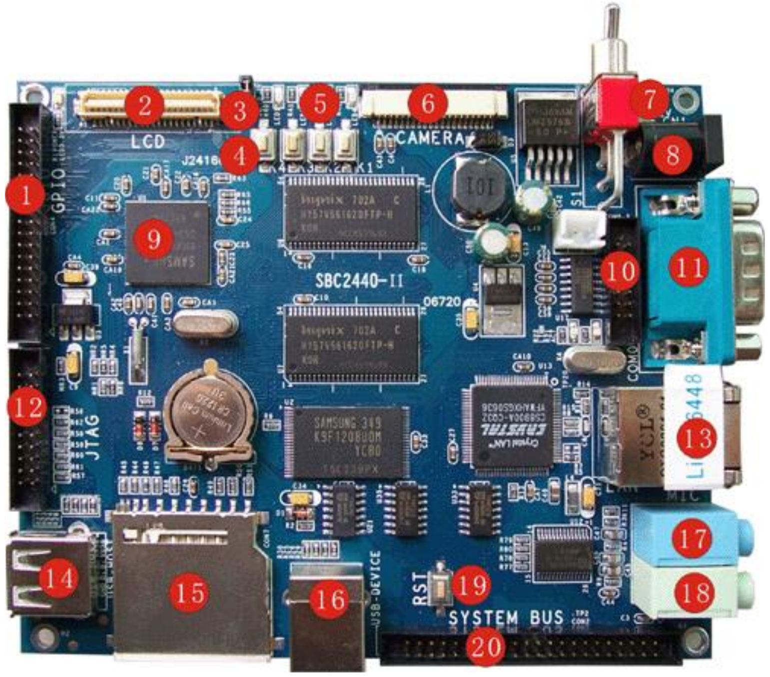
System on chip

Definition (nearly) complete embedded system on a single chip

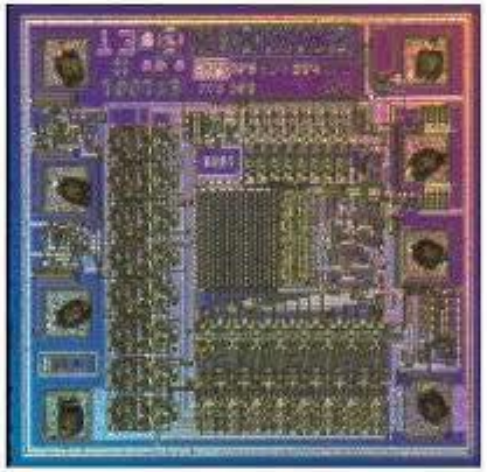
Usually includes Programmable processor(s)
Memory
Accelerating function units
Input/output interfaces
Software
Re-usable intellectual property blocks (HW + SW)

SoC Design Goal





After



Apple “A5” SoC

Used in *iPad 2* and *iPhone 4S*

Manufactured by Samsung *45nm, 12.1 x 10.1 mm*

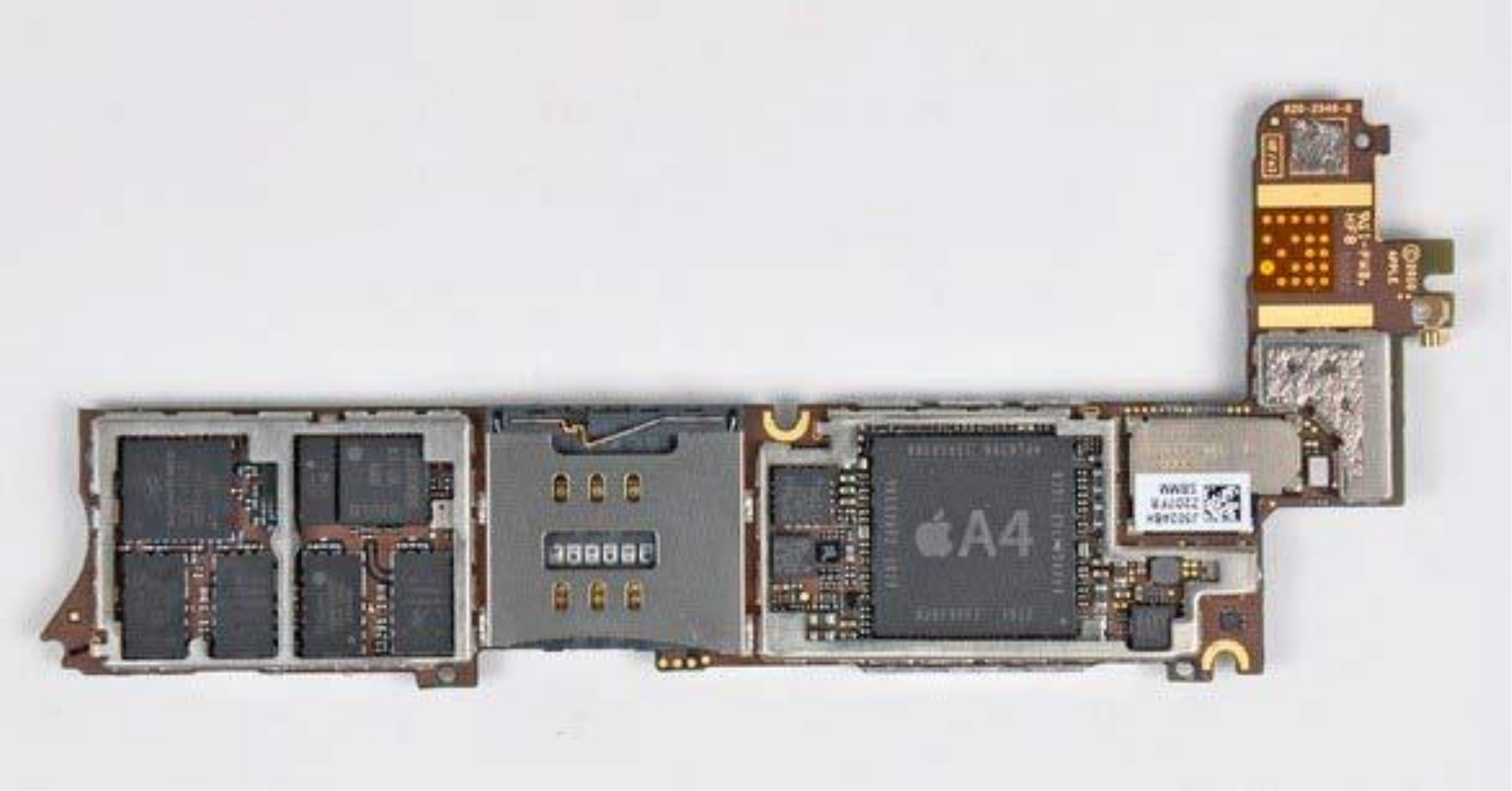
Elements (unofficial): ARM Corex-A9 MPCore CPU - 1GHz NEON SIMD accelerator

Dual core PowerVR SGX543MP2 GPU
Image signal processor (ISP)
Audience “EarSmart” unit for noise canceling
512 MB DDR2 RAM @ 533MHz

iPhone 4 circuit board (with A4 SoC)

PHOTO NEXT

Apple “A5” SoC



Apple Watch 2015

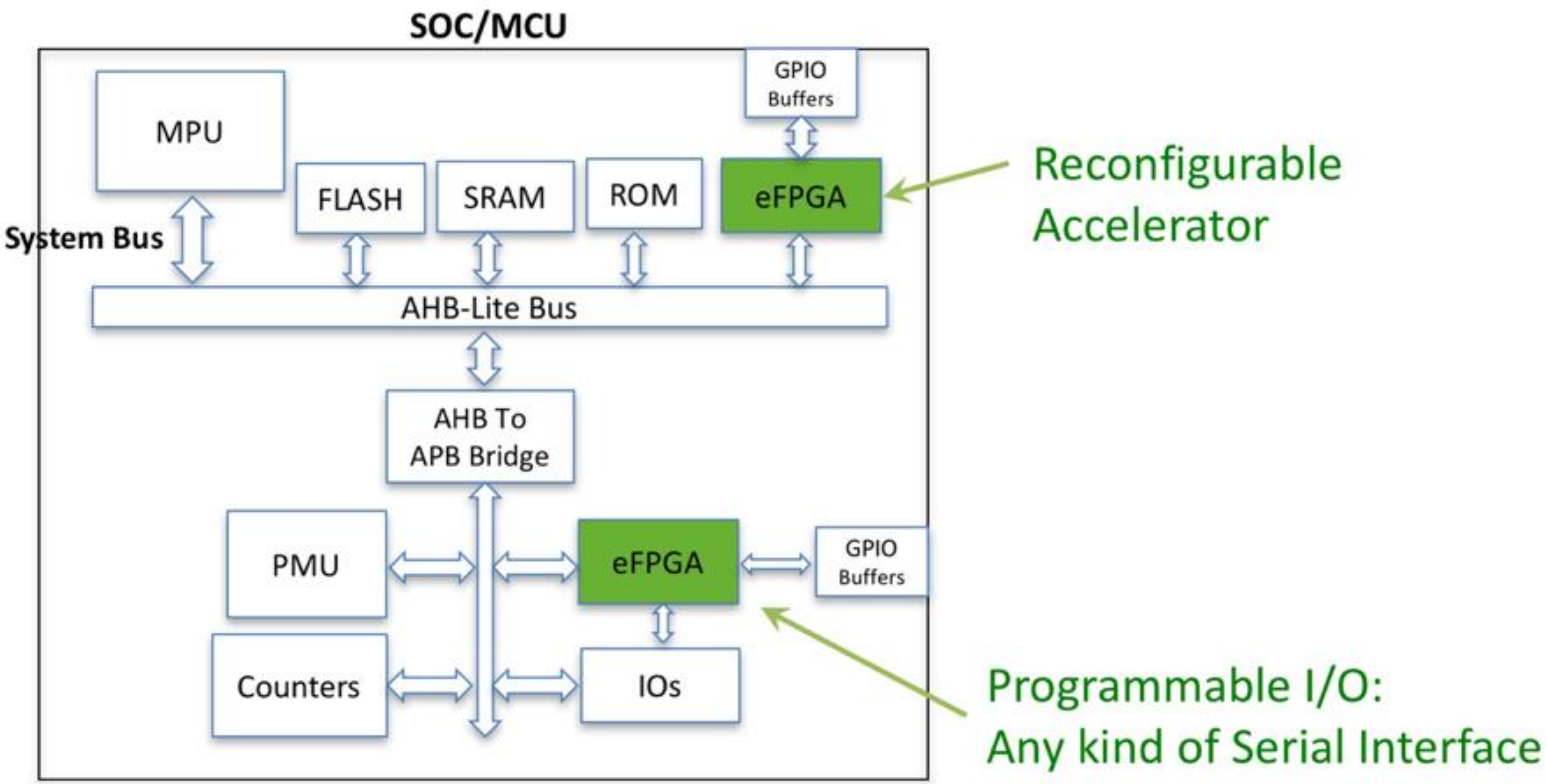
Anyone know Dick Tracy?

Apple CEO Tim Cook suddenly became a little boy again as he showed that [Apple's new smart watch] will also send and receive phone calls.

"I have been wanting to do this since I was 5 years old," Cook exclaimed. "The day is finally here."

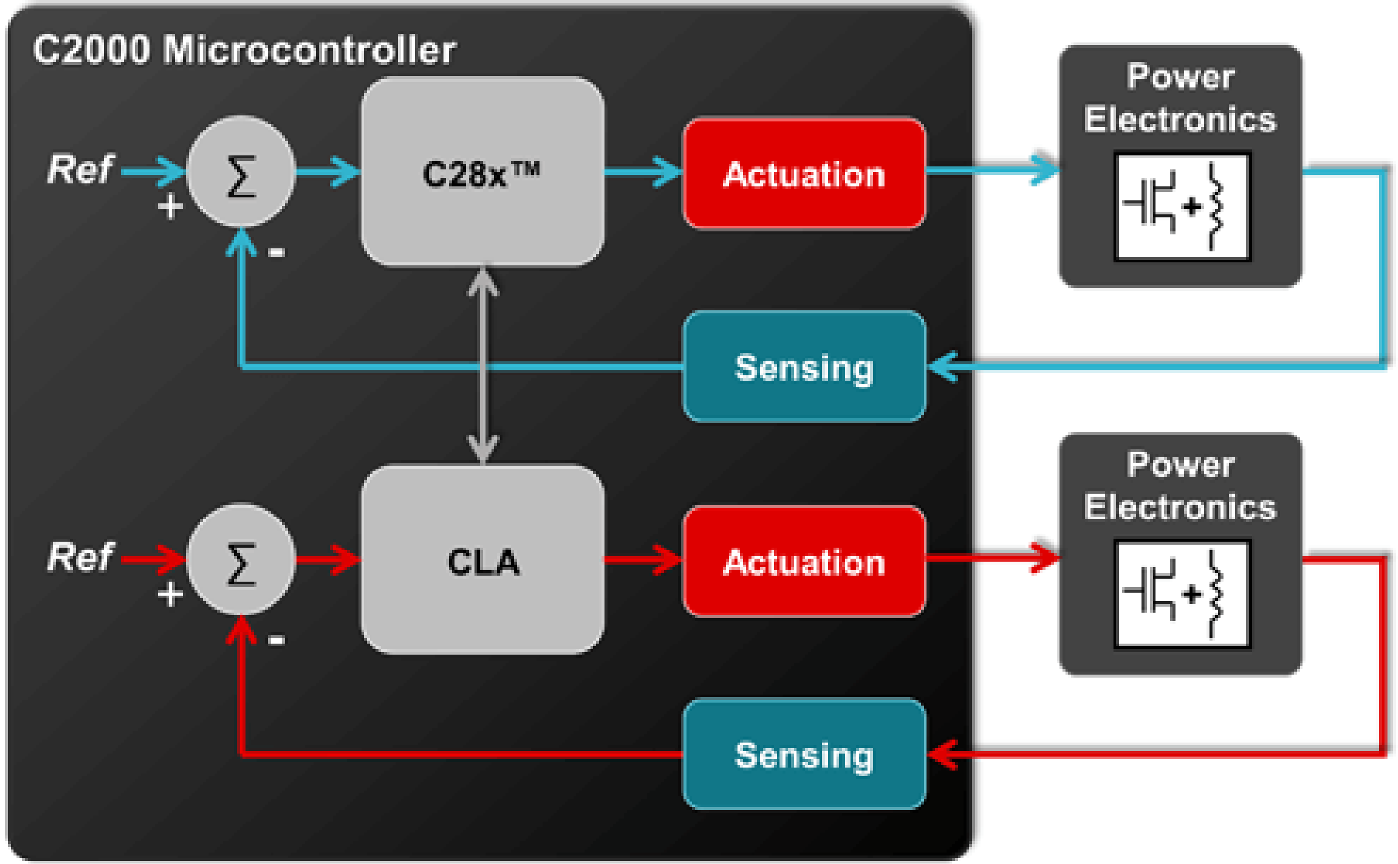
The 54-year-old Cook was harking back to 1965, when any American youngster could tell you that the coolest gizmo around was Dick Tracy's two-way wrist radio.

The Future of Microcontrollers
By Tony Kozaczuk, Director Architecture Solutions, Flex Logix, 11.16.17

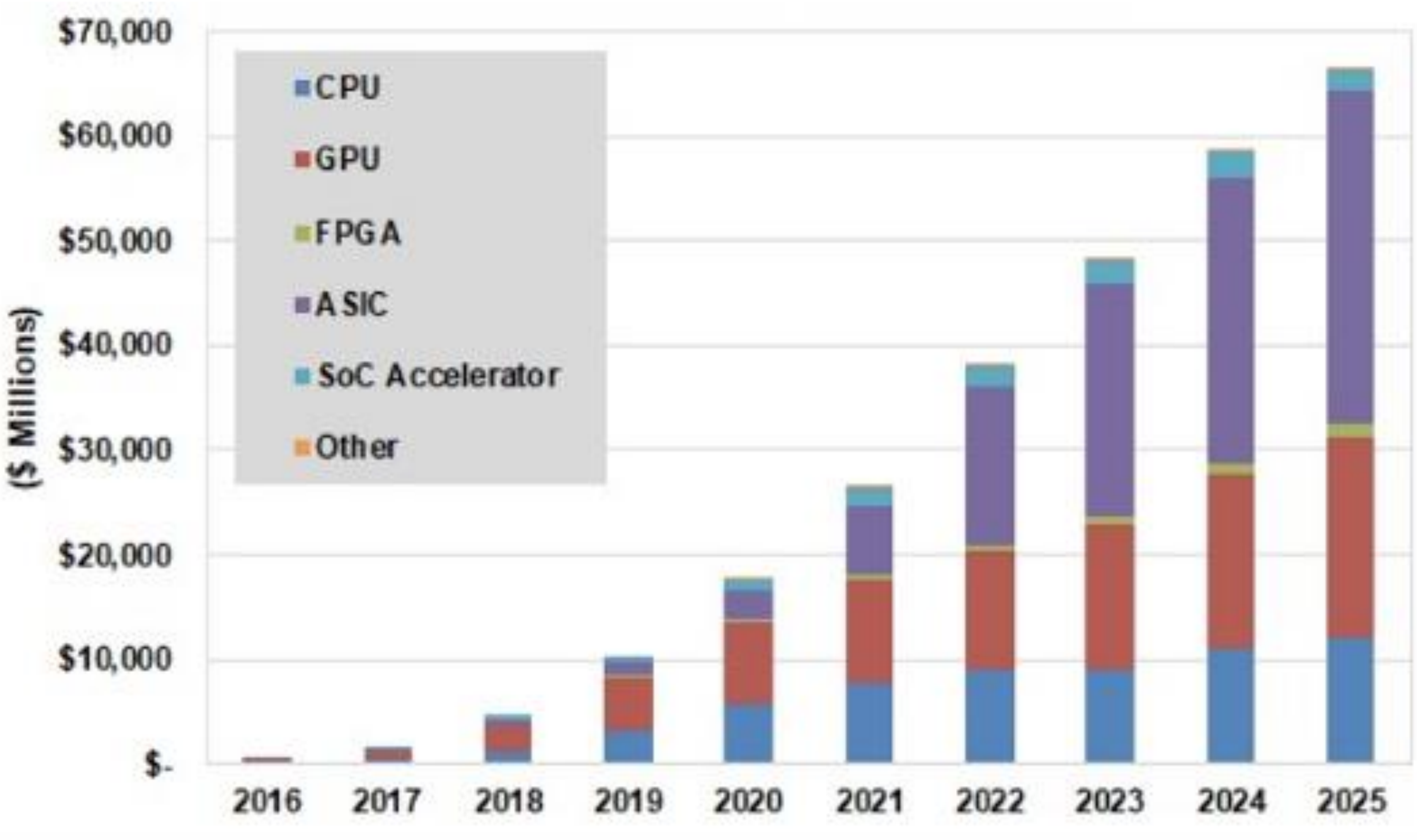


CLA real-time control accelerator

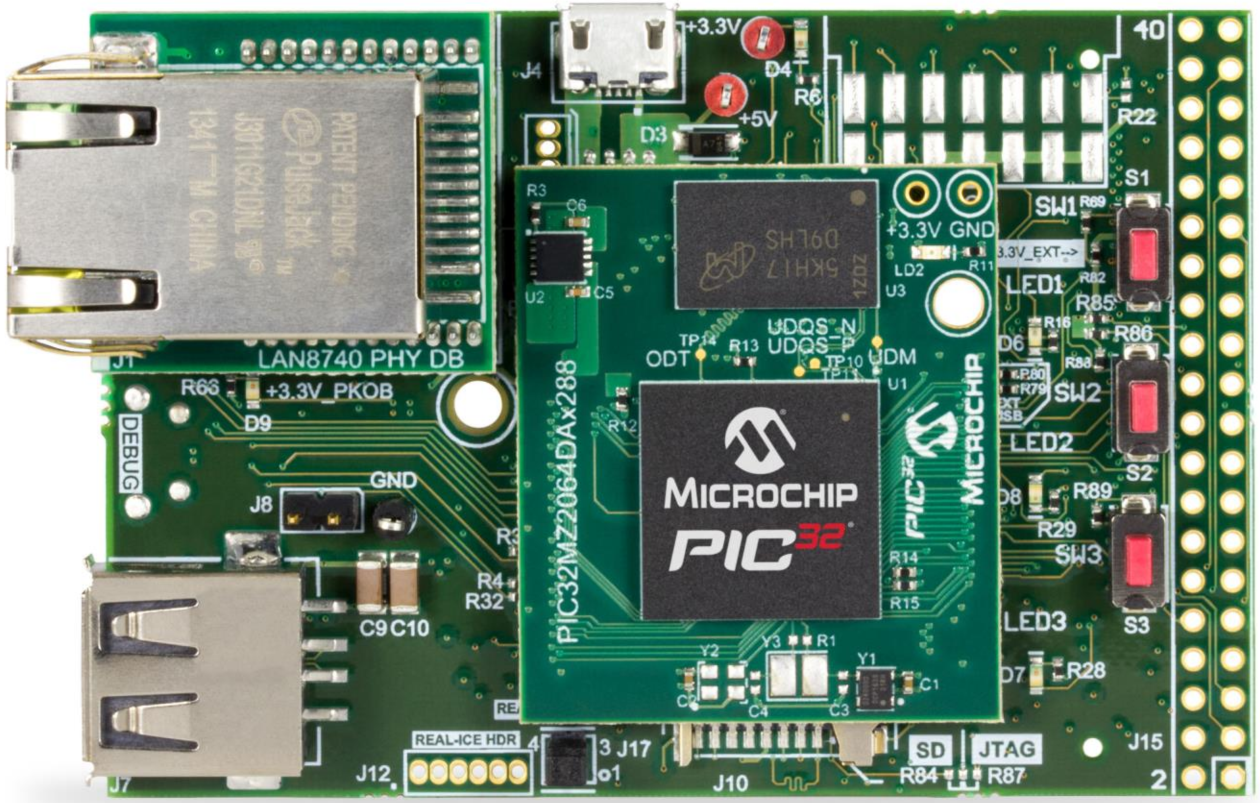
Software flexibility, Hardware deterministic timing!!



http://www.ti.com/lsds/ti/microcontrollers-16-bit-32-bit/c2000-performance/real-time-control/overview.page?DCMP=dsp_C2000&HQS=c2000



Source: Tractica



PIC32MZ Embedded Graphics with External DRAM (DA) Starter Kit
(Part # DM320008)

MICROCHIP

AI Processor Options: Benefits and Trade-Offs

CPUs:

- Universal availability in the cloud
- Flexible across deep learning inference and all other cloud workloads
- Great software tools

LIMITATION: Not high enough performance for training

GPUs:

- Very high performance on both deep learning inference and training
- Wide availability in the cloud
- Flexible across deep learning and some other high-performance computing workloads
- Great software tools

LIMITATION: high power, high cost

FPGAs:

- High performance on deep learning inference and a few other DSP workloads
- Some availability in the cloud
- Energy efficient

LIMITATION: Less mature software, not suited for training

AI Chips:

- Very high performance on deep learning inference and training (depending on chip)
- Usually very energy efficient and cost effective

LIMITATION: Only very early availability especially in cloud; software usually less mature; often applicable only to deep learning tasks

Source: Chris Rowen, BabbleLabs Inc.

Largest semiconductor companies (annual semiconductor sales leaders)

Rank	2018[9]	2017[9]	2011[10]	2006[11]	2000[11]	1995[11]	1992[12]	1990[11]	1986[13]	1985[11]	1975[13]
1	Samsung	Samsung	Intel	Intel	Intel	Intel	NEC	NEC	NEC	NEC	TI
2	Intel	Intel	Samsung	Samsung	Toshiba	NEC	Toshiba	Toshiba	Toshiba	TI	Motorola
3	SK Hynix	TSMC	TSMC	TI	NEC	Toshiba	Intel	Hitachi	Hitachi	Motorola	Philips
4	TSMC	SK Hynix	TI	Toshiba	Samsung	Hitachi	Motorola	Intel	?	Hitachi	?
5	Micron	Micron	Toshiba	ST	TI	Motorola	Hitachi	Motorola	?	Toshiba	?
6	Broadcom	Broadcom	Renesas	Renesas	Motorola	Samsung	TI	Fujitsu	?	Fujitsu	?
7	Qualcomm	Qualcomm	Qualcomm	Hynix	ST	TI	?	Mitsubishi	?	Philips	?
8	Toshiba	TI	ST	Freescale	Hitachi	IBM	Mitsubishi	TI	?	Intel	?
9	TI	Toshiba	Hynix	NXP	Infineon	Mitsubishi	?	Philips	?	National	?
10	Nvidia	Nvidia	Micron	NEC	Philips	Hyundai	?	Matsushita	?	Matsushita	?

Top 10 semiconductor companies across the world, based on their total revenue in 2020.

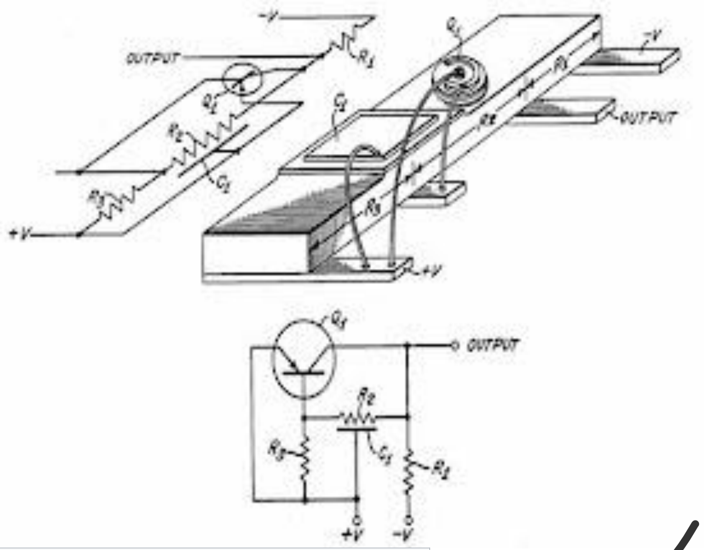
1. Intel (INTC) — Santa Clara, California, United States
2. Samsung Electronics — Yeongtong District, Suwon, South Korea
3. Taiwan Semiconductor Manufacturing Co. (TSMC) — Hsinchu Science Park, Taiwan
4. Full TimeSK Hynix Inc. — Icheon, South Korea
5. Broadcom Corporation — Irvine, California, United States
6. Qualcomm — San Diego, California, United States
7. Micron Technology — Boise, Idaho, United States
8. Applied Materials — Santa Clara, California, United States
9. Nvidia Corporation — Santa Clara, California, United States
10. Texas Instruments Inc. — Dallas, Texas, United States

https://www.zippia.com/advice/largest-semiconductor-companies-world/

The First (2D) Integrated Circuit
Jack Kilby, Texas Instruments, 1958

- Transistor, Resistors and Capacitors on the same piece of semiconductor
- Interconnects between components not integrated

  → Low connectivity between components



Motorola 68000 (16/32-bit, 32-bit registers, 16-bit ALU)	Transistors: 68,000

GPU

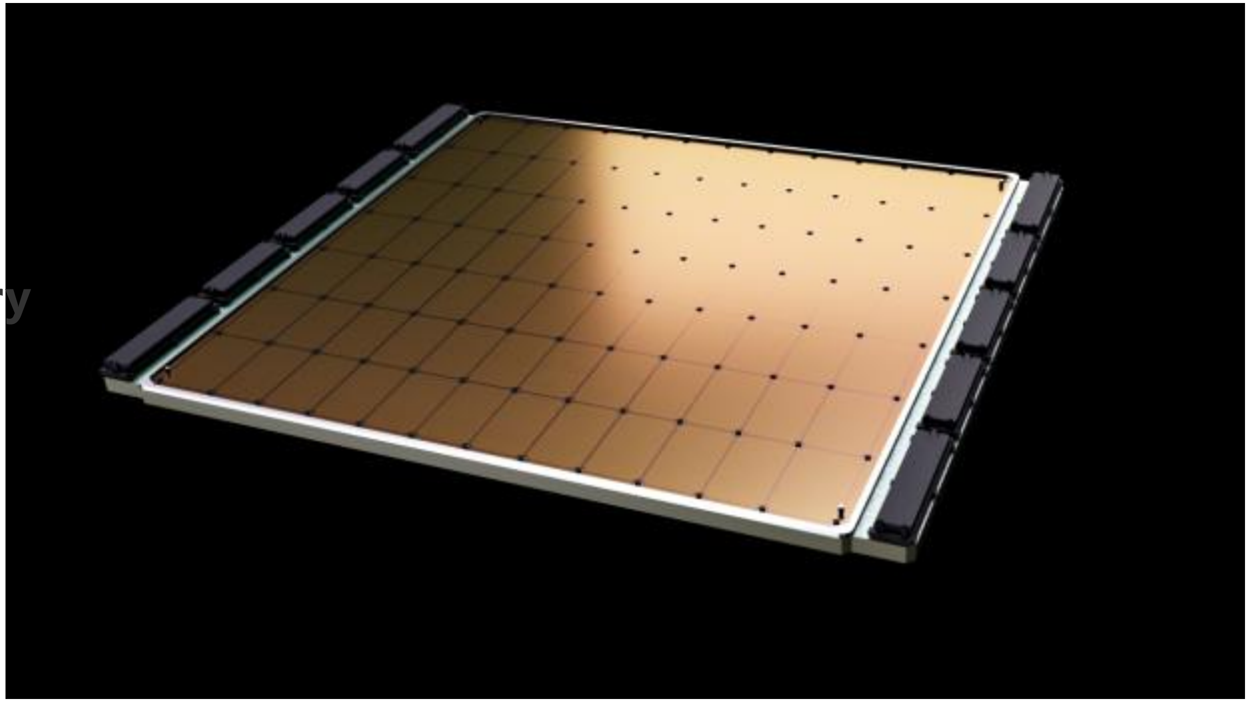
Versal VP1802	92,000,000,000	2021 ?[f]	Xilinx

The world's largest chip: 2.6 trillion transistors and 850,000 cores. Cerebras has the world's largest chip: 2.6 trillion transistors -- that's 2,600,000,000,000 -- with 850,000 cores on TSMC 7nm.Read more: https://www.tweaktown.com/news/74601/the-worlds-largest-chip-2-6-trillion-transistors-and-850-000-cores/index.html

✓

15 kW of Power

square mm of silicon,
GB of on-chip memory



WOW !

My Integrated circuits used a 1 inch wafer