Introduction to the BBC micro:bit

Programming for beginners with the BBC micro:bit

John Davies

Bearsden and Milngavie u3a

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Synopsis

Wikipedia describes the micro:bit as a ‘single-board microcontroller’. The ‘single [printed circuit] board’ part is obvious but what is a **microcontroller**?

By ‘computer’ you probably think of a desktop computer, laptop or smartphone. But your house and other possessions are full of small computers called **microcontrollers** in **embedded systems** that you probably don’t realise are there.

In this talk I’ll cover:

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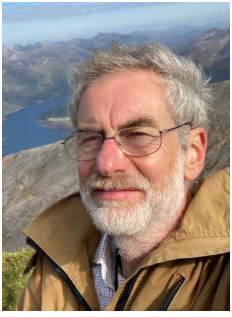
In this talk I’ll cover:

- who am I
- brief history of microprocessors, microcontrollers and embedded systems
- examples of embedded systems in daily life
- main components of a small microcontroller (computer in embedded system)
- ARM, a major provider of designs for processors, based in Cambridge
- the BBC micro:bit

About me

- Worked in James Watt School of Engineering at University of Glasgow, 1986–2020.
  - Most research was on tiny semiconductor devices
  - Taught microcontrollers and embedded systems from 2000: lectures, labs, team projects, individual projects.
  - Led academic aspects of transnational education in Singapore and Chengdu, China.
  - Dean of Learning and Teaching for Science and Engineering, 2014–2019.



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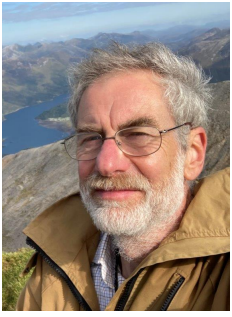

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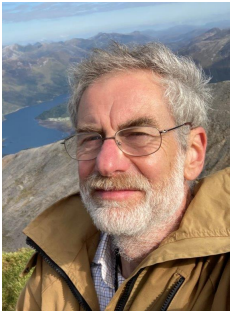

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The *Atlas* family – Chilton upper floor (1964–1973)

Punched cards, paper tape, lineprinter, magnetic tapes, ...

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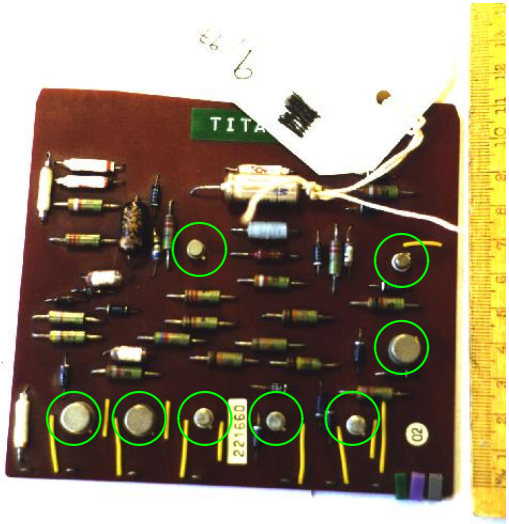
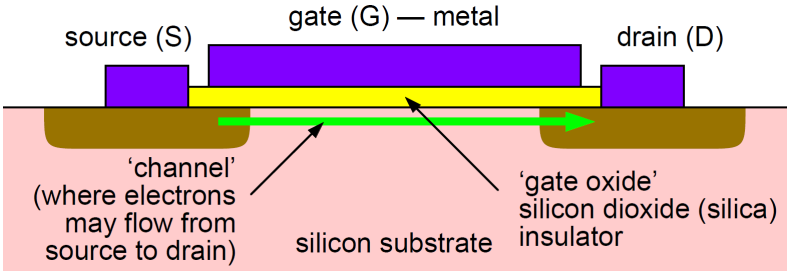


What are transistors and integrated circuits?

Digital circuits work in binary – 0s and 1s – and operate by opening and closing switches. In silicon the switches are a type of transistor called a MOSFET. Here is a wildly over-simplified sketch of an antique device.



The voltage on the **gate** opens and closes the **channel**, through which current flows between the **source** and **drain**.

MOSFETs come in two complementary 'polarities', hence the **C** in **CMOS**. Many transistors are connected on the silicon to form an **integrated circuit** (**IC** or **chip**).

Developments over the decades

A smartphone out-performs any of the computers that I have shown. The advances are driven by astonishing developments in integrated circuits (ICs or chips). A large IC contains *billions* of transistors, whose length is now below 10 nm (10×10^{-9} m): around 100 atoms long. Smaller transistors are faster and use less power.

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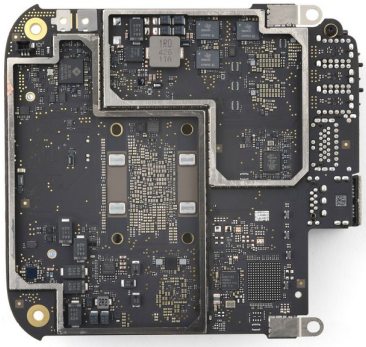
- By 1971 an integrated circuit could hold the complete central processing unit (CPU) of a computer: the **microprocessor**. This led to microcomputers, including the BBC Micro.

  Microprocessors increased speed, power and complexity: multiple cores. . . .

  Current examples in personal computers: Intel Core, AMD Ryzen, Apple M4.

Inside a Mac mini



Top and bottom of the main circuit board, about 110 mm square.

Other components: communications, specialised memories, clocks, power…

From iFixit's Repair Guide to the Mac mini (2024).

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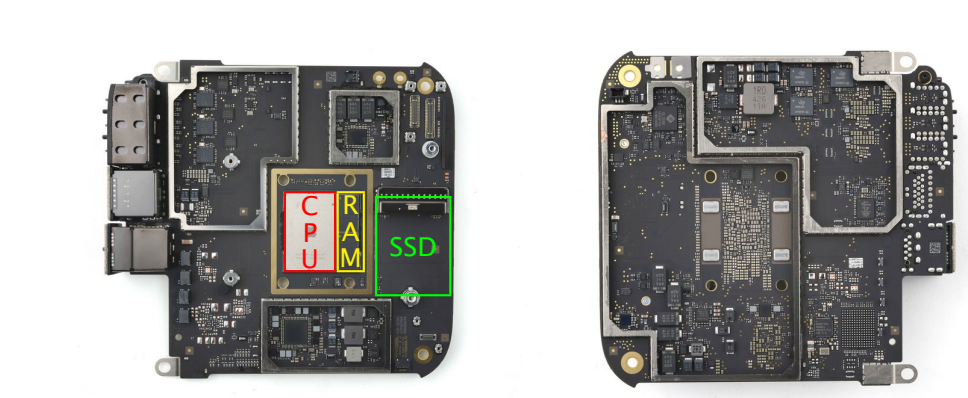

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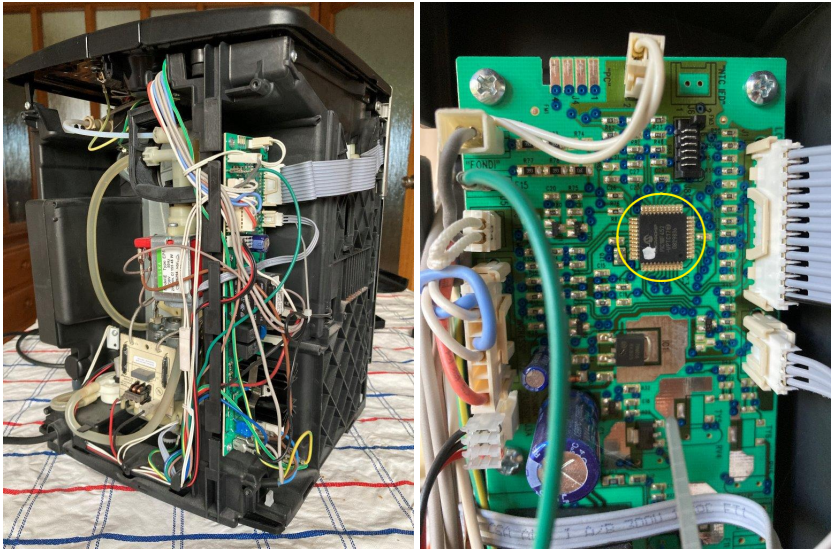
Most digital processors are in microcontrollers rather than microprocessors.

Microelectronics in the kitchen

How many of these products rely on (digital) electronics?

Inside the coffee maker



Internet of Things

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Example: domestic heating from tado°.

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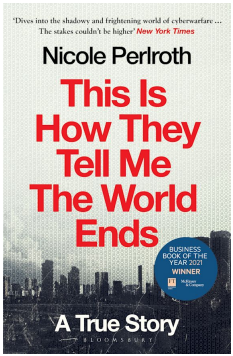
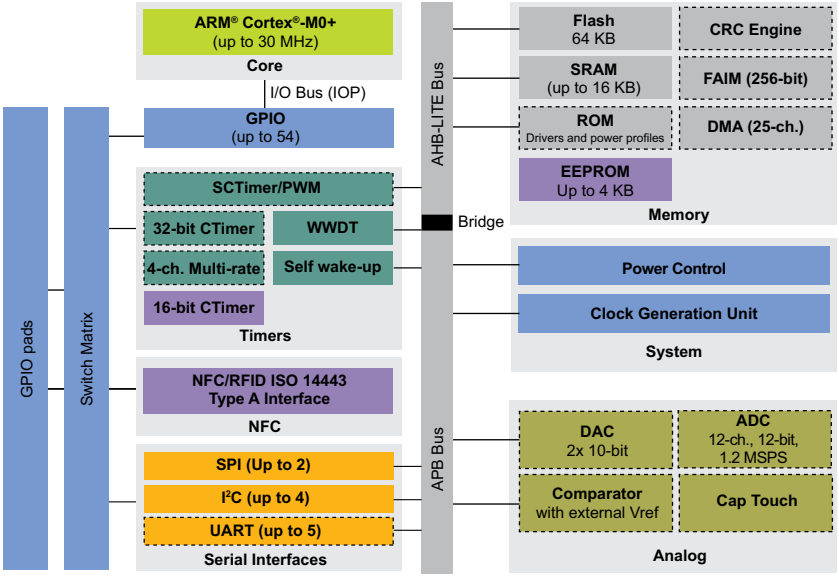


Example of MCU: NXP LPC800, introduced 2017, cost from 30p



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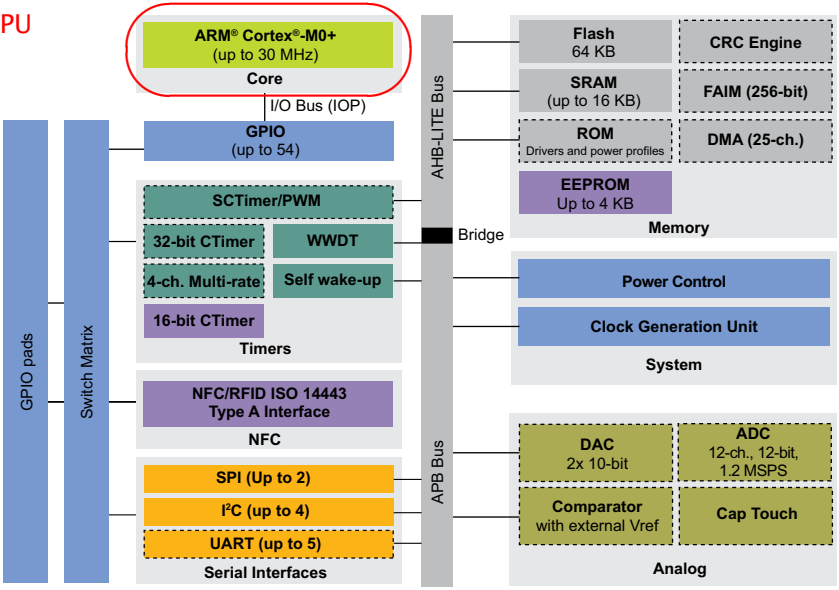
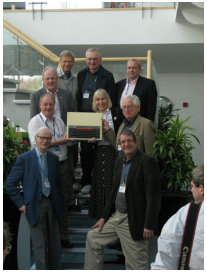
32-bit ARM CPU



ARM – Brief history

From  to  to 

- Acorn Computers founded 1978; launched BBC Microcomputer in 1981.
- ARM RISC processor family introduced 1985; taken up by Apple and DEC.
- ARM was spun off in November 1990 to focus on the **design of processors**.
- The Japanese SoftBank Group bought ARM for £24 billion in 2016.
- Some shares in ARM are now traded on the US NASDAQ stock market, 2023.

Creators of BBC Micro (Wikipedia, 2012); Nokia 5110 (1998); Apple M1 chip, 2020.

From the BBC Micro to the micro:bit

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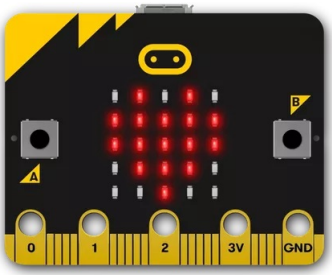

The **BBC micro:bit** (2016) is a single-board *microcontroller*: programs are written on a separate computer and downloaded; it can be built into a larger system.

Micro:bit call this **physical computing** – engineers would say an **embedded system**.

History and philosophy of the micro:bit

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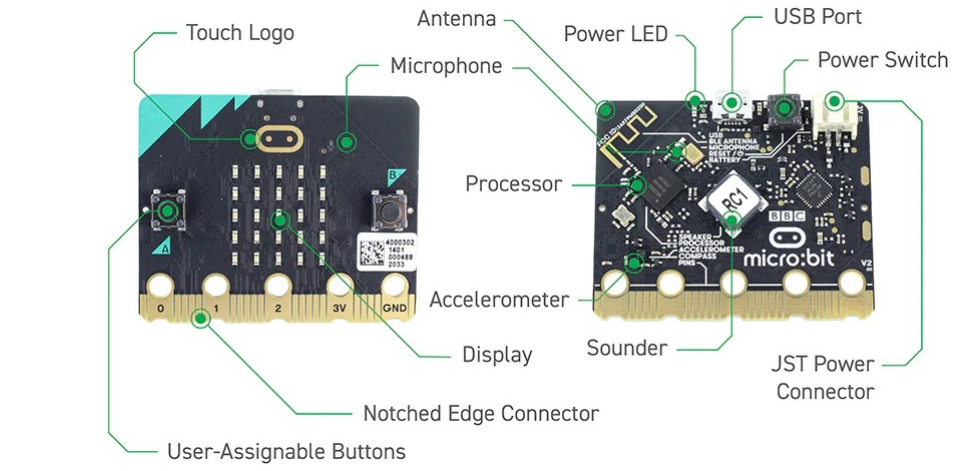
- Led by the Micro:bit Education Foundation since 2016. The micro:bit is used worldwide and the British Council is a partner.

Features of the micro:bit



All this on half a credit card! The two buttons are labelled A and B. The processor includes a temperature sensor. The USB interface chip (right) is not labelled.

Prospectus

Here is the outline of the practical sessions.

1. **First program: Hello!** – a simple program to get familiar with the MakeCode application (or web page) for constructing the program and with downloading the program to the micro:bit with USB or Bluetooth.
2. **Handling inputs** – responding to the pushbuttons, the simplest type of input.
3. **Variables** – data that change while a program runs, which we shall use to construct a dice with the traditional patterns of dots.
4. **Radio** – micro:bits can send short messages to each other, which we shall use to simulate a swarm of micro:bits that flash in synchronisation.

Further slides cover:

- Tips for using MakeCode, text-based languages as an alternative to blocks, and what goes on 'behind the scenes' of your program
- Functions and how to use them, a vital tool for larger programs

Information on the micro:bit

A *vast* amount of information is available on the micro:bit. This course is based heavily on the following web sites, particularly the home site microbit.org.

- Home site for BBC micro:bit microbit.org, extremely informative, including:
  - Getting started
  - User guide
  - Let's code
  - Mobile apps for iPad and Android tablets
  - Lots of example projects, some of which we shall try
- Microsoft MakeCode, which we shall use to construct our programs
- MakeCode reference and micro:bit Help and Support
- micro:bit developer community for greater technical depth
- Wikipedia page, with a large number of further links
- British Council working across the world in partnership with micro:bit