Introduction to microcontrollers

LAB INTRODUCTION

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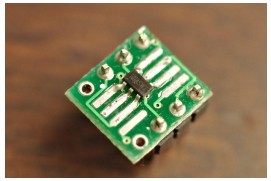
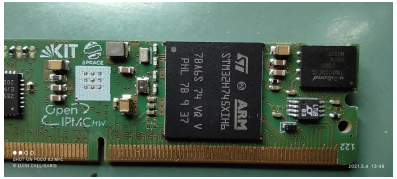
What is a microcontroller (MCU)?

- A semiconductor processing device which is:
  - Self-contained → just needs power to run
  - General-purpose → you can write a program in C for it
  - Embedded peripherals → interfaces & coprocessors
  - Relatively cheap → can be mass-deployed
- Overlaps w/ Systems on a Chip (SoC), System-in-package (SIP)
  - There is a continuous spectrum of devices on the market
    - SoC → Aim OS (Linux, Android, …) applications, does not include DRAM
    - SIP → Like a SoC, but fully self-contained DRAM
    - MCU → Aim bare-metal and RTOS (Real-Time Operating System)
- Bare-metal: your program has full control of the device
- RTOS: a scheduler helps to execute multiple “tasks”
- MCUs are ***everywhere*** (cars, phones, coffee machines...)



Padauk PMS150C-S08
an 8-bit MCU costing just 3 dollar cents
(picture credit: A.B.Nielsen)

Atmel ATmega328P
Basis of the popular Arduino Uno board



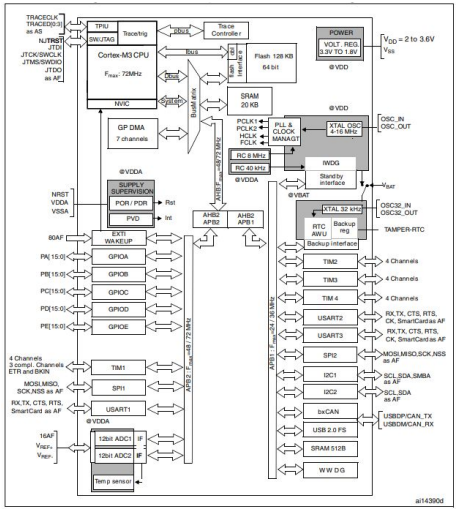
ST Microelectronics STM32H745
a powerful 480MHz ARM MCU

(left) Allwinner V3s, a SIP used in cameras

(right) Zynq Ultrascale+ EG, a line of SoCs with embedded programmable FPGA logic

Why MCUs are useful to you

- You will use electronics in your research & professional activity
  - This is particularly important if you plan to work on hardware
  - Most of these devices contain one or more MCUs, for example:
    - FPGA board management & boot
    - Low-power IOT devices & sensors
    - Medical and high-reliability devices
- Many applications can employ a cheap microcontroller
  - Data acquisition at low to medium (order of 1 MHz) rates
  - Device control and health monitoring
  - Lab (or even home) automation (e.g. USB-controlled board reset)
  - A microcontroller is a powerful tool in your box
- Code written in C is usually easily portable
- Boards are cheap enough that you can get one for yourself
  - Original ST and NXP boards sell for 15-30$, cheaper ones for 5-10$

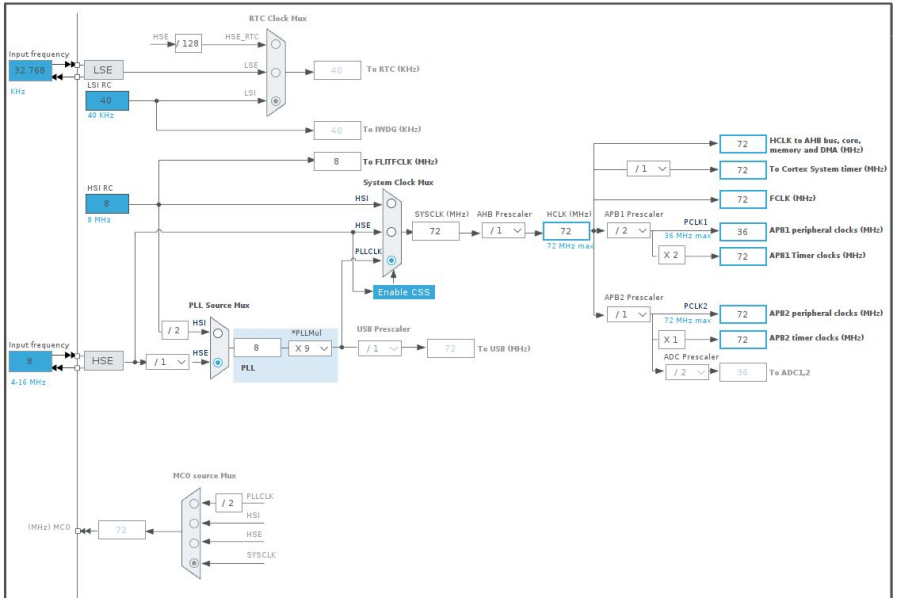


Internal layout of STM32F103 MCU
Many many peripherals to use

An NXP mbed LPC1768 development board

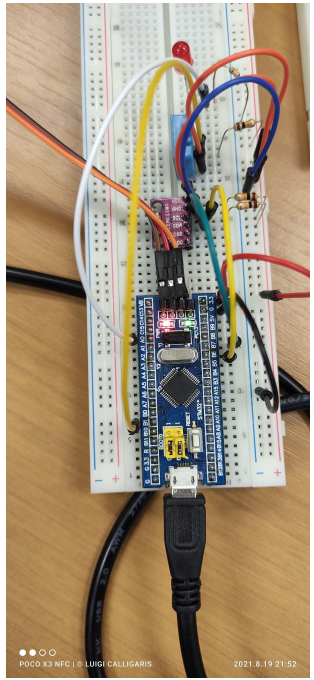
What do I plan to show in this lab

- Using the official ST dev environment, STM32CubeIDE
  - We'll learn how to configure the MCU in the IDE
  - We'll take a look at example code to read out:
    - A Bosch BMP280 pressure sensor
    - An Asair DHT11 temperature sensor
  - We'll learn how to generate an analog waveform from purely binary output
    - PWM modulation of a led



How this laboratory will be ran

- Due to covid travel uncertainty, I won't be flying to Madrid from Brazil
- The microcontroller boards can be accessed remotely from UAM
  - X2GO session directly to São Paulo to operate the boards
- I'll be present remotely over Discord to guide your steps
  - This can be used to talk and share the session
- We have 3-4 STM32F103 boards to play with
  - Pressure sensor BME280
  - Temperature sensor DHT11

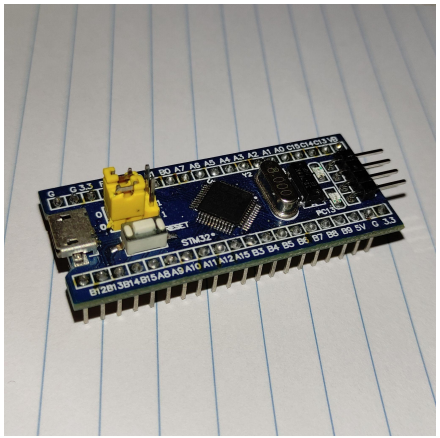


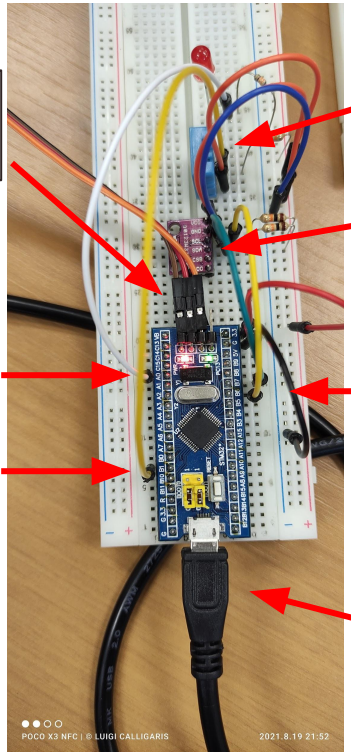
Info for the participants/1

- It’s recommended to have at least introductory knowledge of:
  - Linux (we will use Kubuntu 20.04)
  - C programming language (e.g. you should know how to pass a pointer)
- Discord Server invite link: https://discord.gg/8CUBtmEjzm
  - Join the voice channel “General”
  - To text chat, join the channel #general
- Launch the application “X2GO” and click on the already-saved connection

Info for the participants/2

- We will use an STM32F103C8T6 microcontroller in a “Blue Pill” board
- Documentation
  - MCU Datasheet
  - Ref manual





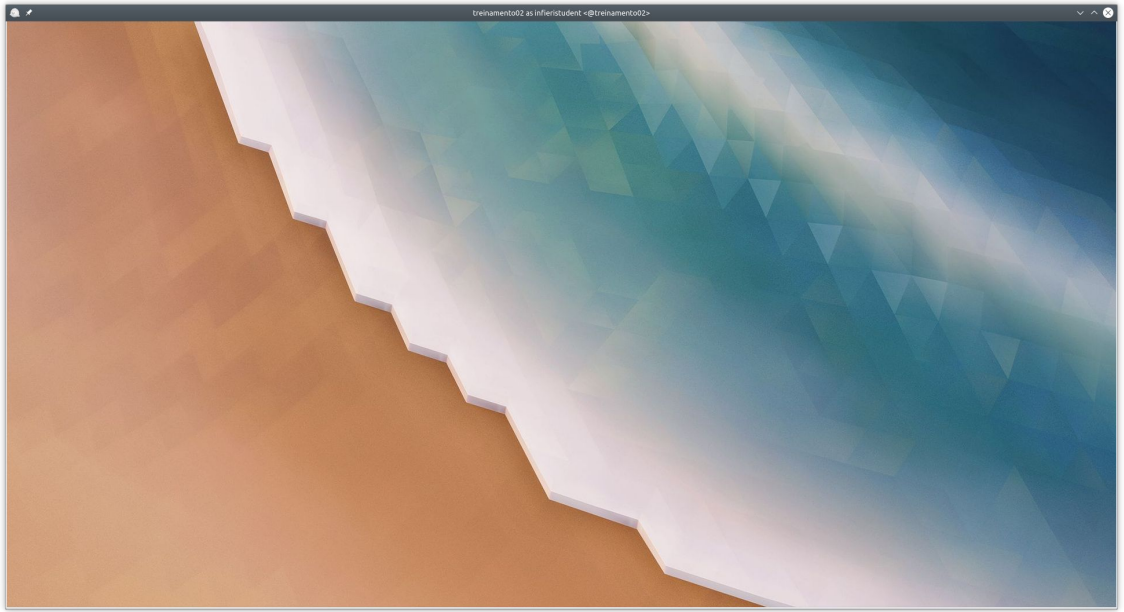
Updated instructions link

- The instructions in these slides will be updated over time
- Link to get the updated slides:
  - https://docs.google.com/presentation/d/1pjYwRkZg3T7OdJ_RLjd8rSzSbYRe6-PI60GxalDYr-I/edit?usp=sharing

In-detail instructions for the lab

Adjusting X2GO screen resolution/1

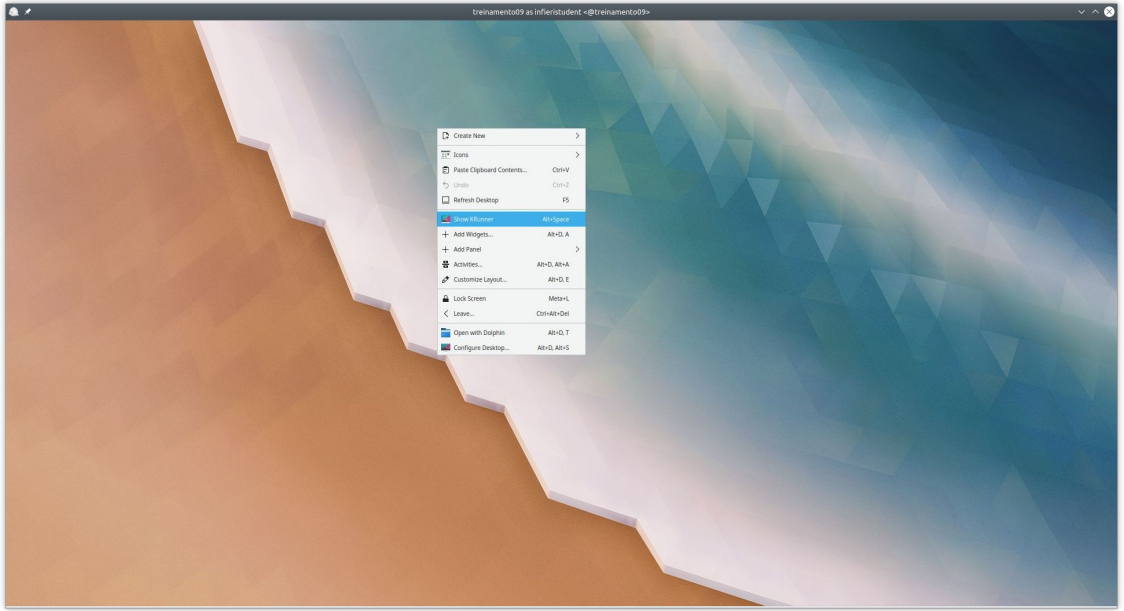
- If you see this when connecting via X2GO, the screen does not fit



- Let’s fix the resolution!

Adjusting X2GO screen resolution/2

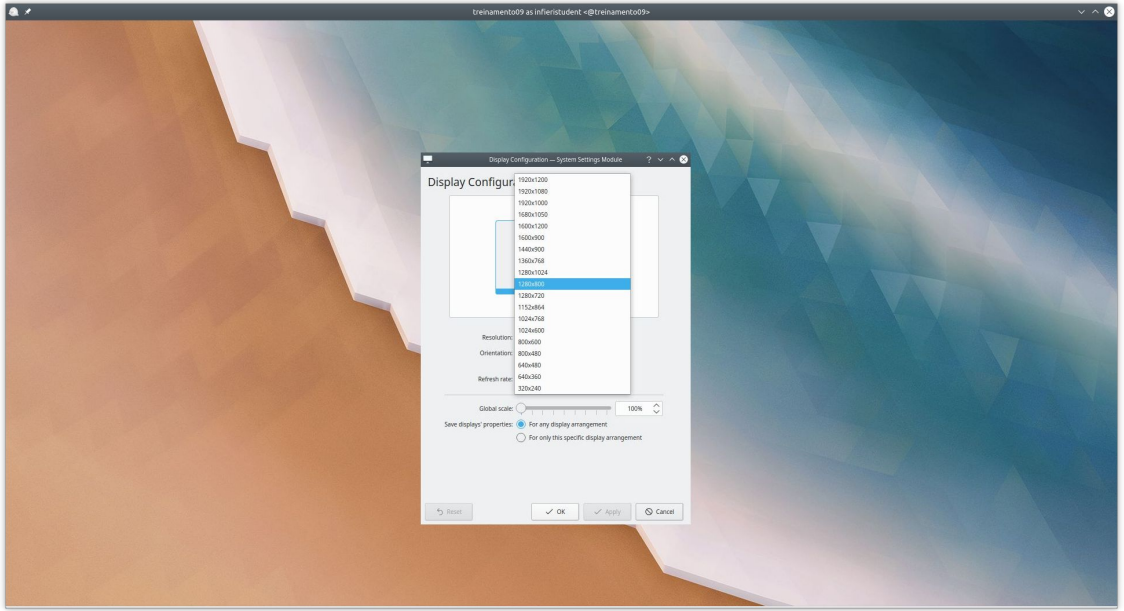
- Right-click on the desktop and select “Show krunner”



- Write “Display” and click on “Display configuration”

Adjusting X2GO screen resolution/3

- Choose a suitable resolution, e.g. 1280x1024



- Click the “Apply” button to set the resolution