II2260
SISTEM EMBEDDED

Sekolah Teknik Elektro dan Informatika

INSTITUT TEKNOLOGI BANDUNG

Pengantar
Sistem Embedded

1.1 Pengantar

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Pengertian Sistem Embedded Secara Bahasa

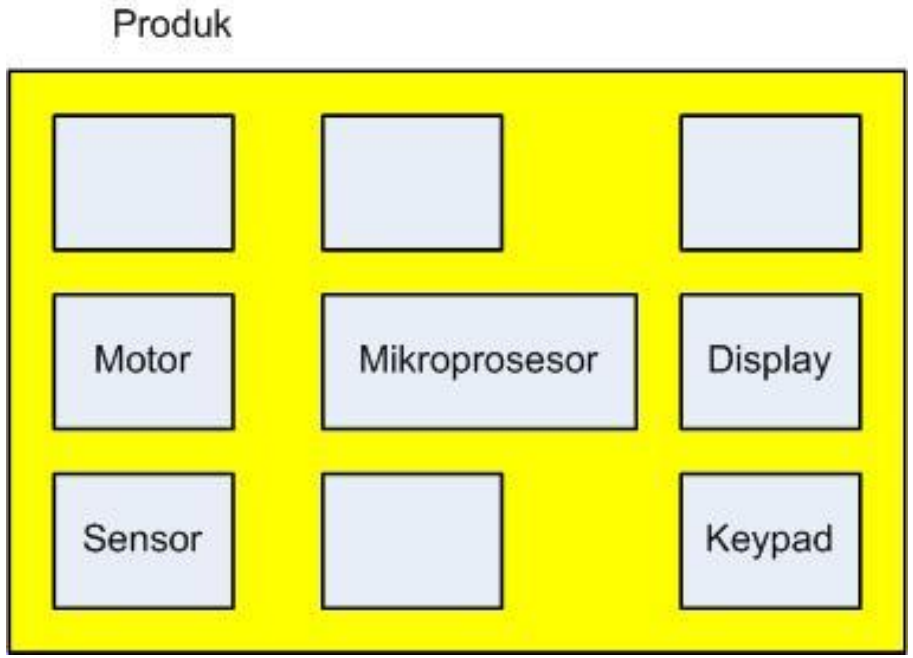
1. occurring as a grammatical constituent (such as a verb phrase or clause) within a like constituent
2. **enclosed closely in or as if in a matrix : set firmly into a mass or material**
3. attached to a military unit or group for some purpose (such as covering a conflict or providing expert advice)

"Embedded." *Merriam-Webster.com Dictionary*, Merriam-Webster, https://www.merriam-webster.com/dictionary/embedded . Accessed 25 Aug. 2020.

Pengertian Sistem Embedded Secara Teknis (1)

- "*Embedded systems are information processing systems embedded into enclosing products*".

Sumber: Peter Marwedel, Embedded System Design 3rd edition, Springer 2018, halaman 2



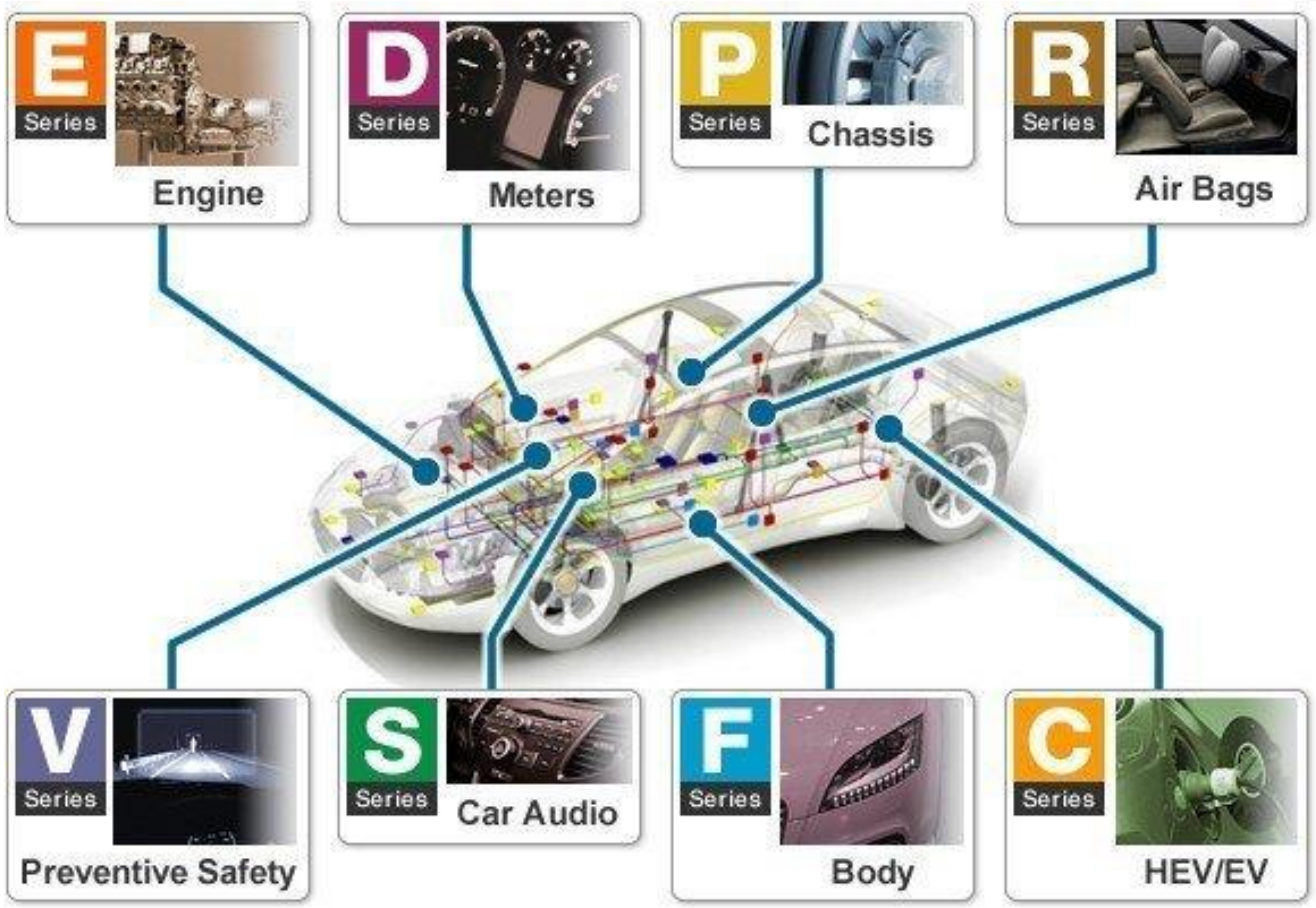
Pengertian Sistem Embedded Secara Teknis (2)

- "**An embedded system is any application where a dedicated computer is built right into the system**" [Jack Ganssle, The Art of Designing Embedded Systems, 2nd Edition, Newnes, 2008]
- **An application that contains at least one programmable computer (uC, uP or DSP) and which is used by individuals who are in the main, unaware that the system is computer based**. [Pont, M.J. , Patterns for Time Triggered Embedded Systems, (2001)]
- **Any computer system hidden in any products** , [David E. Simon, An Embedded Software Primer ,Addison-Wesley Professional; 1st edition (1999)]

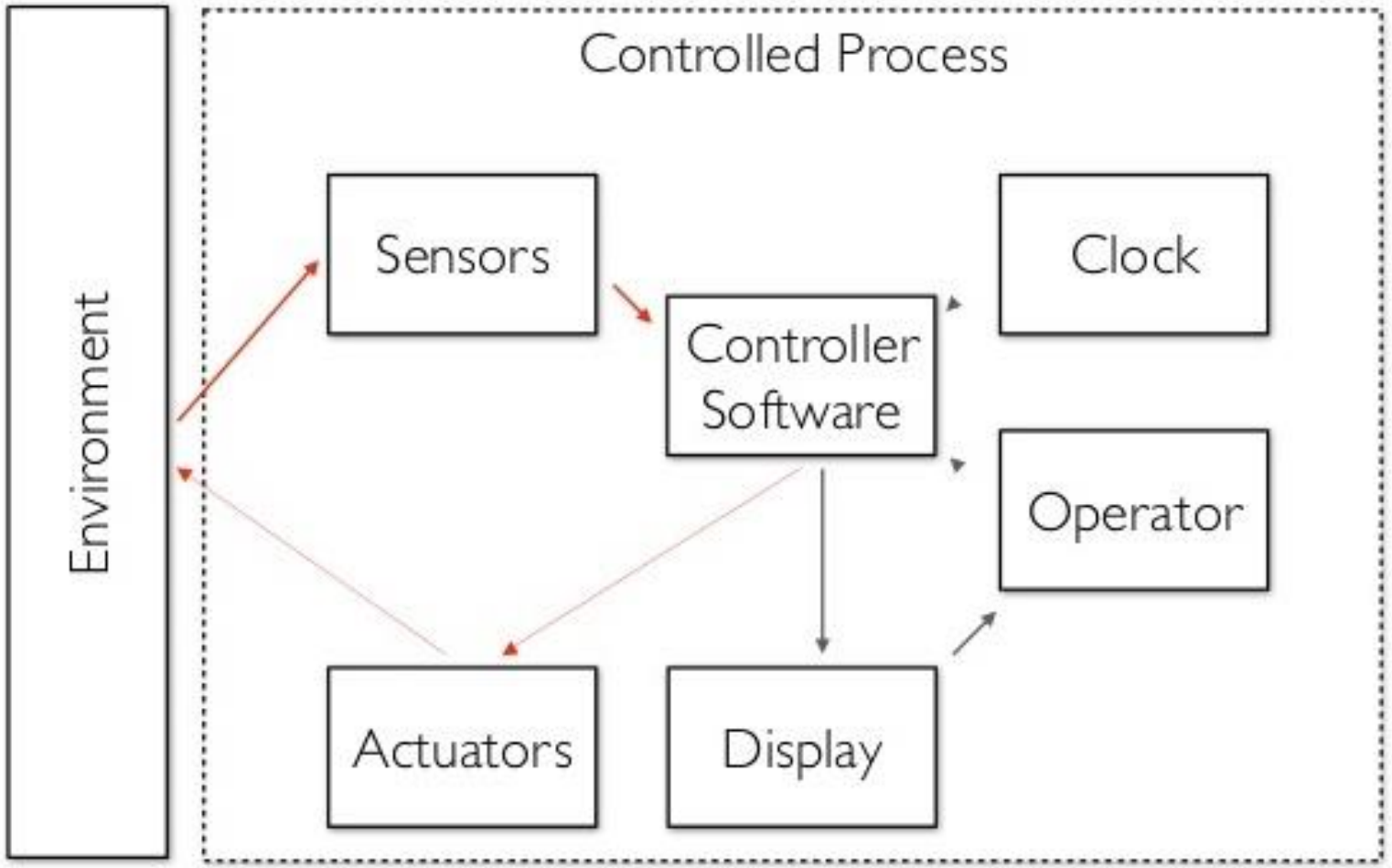
Sistem Embedded

Microprocessor- or microcontroller-based system of hardware and software

Designed to **perform dedicated functions,** within a larger mechanical or electrical system



Sistem Embedded



https://www.omnisci.com/technical-glossary/embedded-systems

What is an Embedded System?

An embedded system is:

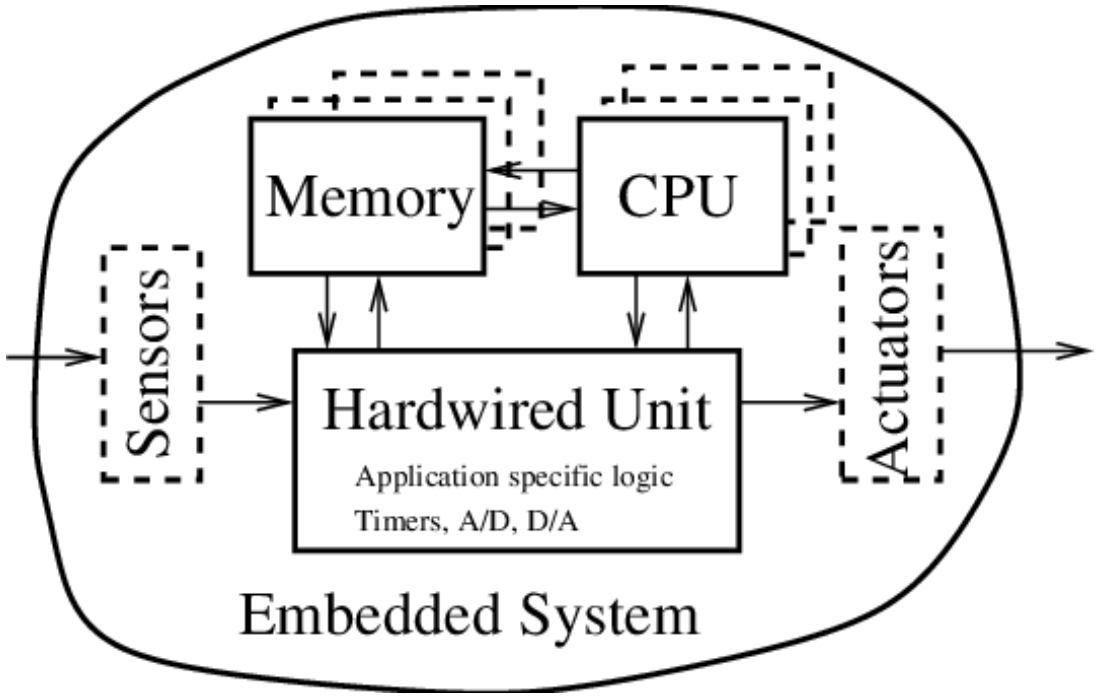
- a **microprocessor-based** computer hardware system with software
- that is designed to **perform a dedicated function**, either as an **independent system or as a part of a large system**.
- At the core is an integrated circuit designed to carry out **computation for real-time operations**.

What is an Embedded System?

- **Complexities** range from a **single microcontroller to a suite of processors** with connected peripherals and networks
  - from **no user interface to complex graphical user interfaces**.
  - The complexity of an embedded system varies significantly **depending on the task for which it is designed**.
- **Embedded system applications** range from digital watches and microwaves to hybrid vehicles and avionics.
  - As much as 98 percent of all microprocessors manufactured are used in embedded systems.

How an Embedded System Works

- **Embedded systems are managed by microcontrollers**, or digital signal processors (DSP), application-specific integrated circuits (ASIC), field-programmable gate arrays (FPGA), GPU technology, and gate arrays.
  - These processing systems are integrated with components dedicated to handling electric and/or mechanical interfacing.
- **Embedded systems programming instructions**, referred to as firmware, are stored in read-only memory or flash memory chips, running with limited computer hardware resources.



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Basic Structure of an Embedded System

The basic structure of an embedded system includes the following components:

1. **Sensor**: The sensor measures and converts the physical quantity to an electrical signal, which can then be read by an embedded systems engineer or any electronic instrument. A sensor stores the measured quantity to the memory.
2. **A-D Converter**: An analog-to-digital converter converts the analog signal sent by the sensor into a digital signal.
3. **Processor & ASICs**: Processors assess the data to measure the output and store it to the memory.
4. **D-A Converter**: A digital-to-analog converter changes the digital data fed by the processor to analog data
5. **Actuator**: An actuator compares the output given by the D-A Converter to the actual output stored and stores the approved output.
6. **Display**: shows measurement result from sensor reading

Modul 1. Pengantar
Sistem Embedded

1.2 Aplikasi

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Applications of Embedded Systems

- Home Appliances
- Fitness trackers
- GPS systems
- Banking Sector
- ATMs
- Medical devices
- Interactive kiosks
- Signal Systems
- Transit and fare collection
- Electric vehicle charging stations
- Automotive systems
- Automobiles Sector
- Central heating systems
- Factory robots
- Defense and Aerospace

Future Trends in Embedded System

- The industry for embedded systems is expected to continue growing rapidly, driven by the continued development of **Artificial Intelligence (AI), Virtual Reality (VR) and Augmented Reality (AR), machine learning , deep learning, and the Internet of Things (IoT)**.
- **The cognitive embedded system** will be at the heart of such trends as: reduced energy consumption, improved security for embedded devices, cloud connectivity and mesh networking, deep learning applications, and visualization tools with real time data.
- According to a 2018 report published by QYResearch, the global market for the embedded systems industry was valued at $68.9 billion in 2017 and is expected to rise to $105.7 billion by the end of 2025.

https://www.omnisci.com/technical-glossary/embedded-systems

Visiting Embedded World 2019, Germany

Visiting Embedded World 2019, Germany

Challenge on Embedded System

Industry 4.0 applications

- Rugged design for **harsh environment** (Ingress Protection - IP rating, extreme temperature)
- **IIoT (Industrial IoT) Factory** (machine vision, voice control, edge computing)
- **Smart Transportation** (anti-vibration and shock, ignition control, etc)
- **Adaptive Display Platform** (modular and rugged design, configure by demand, easy installation and maintenance)
- **Effortless Design** (make embedded system development easy)

Modul 1. Pengantar
Sistem Embedded

1.3 Rencana Perkuliahan

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Mempelajari

- dasar-dasar dan konsep sistem komputer,
- sistem mikroprosesor dan
- sistem embedded.
- Rancang bangun sistem rekayasa embedded berbasis mikrokontroller.

integrasi antara

- perangkat keras (sistem mikroprosesor, sistem sensor, sistem komunikasi),
- perangkat lunak (pemrograman mikrokontroller,
- pemrograman internet, pemrograman client/server, user interaction),
- jaringan komputer (komunikasi data wireless, web server, database server).

Agenda II2260 Sistem Embedded

1. Pengantar Sistem Embedded
2. Mikroprosesor, Mikrokontroler dan Sistem Embedded
3. Pengembangan Sistem Embedded (Metode dan Tools)
4. Input dan Output (Digital/Analog, Monitoring and Control)
5. Sensors (Proprioception/Internal Sensor)
6. Sensors (Exteroception/ External Sensor)
7. Display
8. Communication Protocol and Bus Interface
9. Wireless Communication - Bluetooth
10. Wi-Fi Communication
11. Web Server
12. Database
13. Data Visualization
14. Data Logging
15. Embedded System Engineering Design

WORLD ECONOMIC FORUM

Top 10 Skills of 2025

Type of skill
- Problem-solving
- Self-management
- Working with people
- Technology use and development

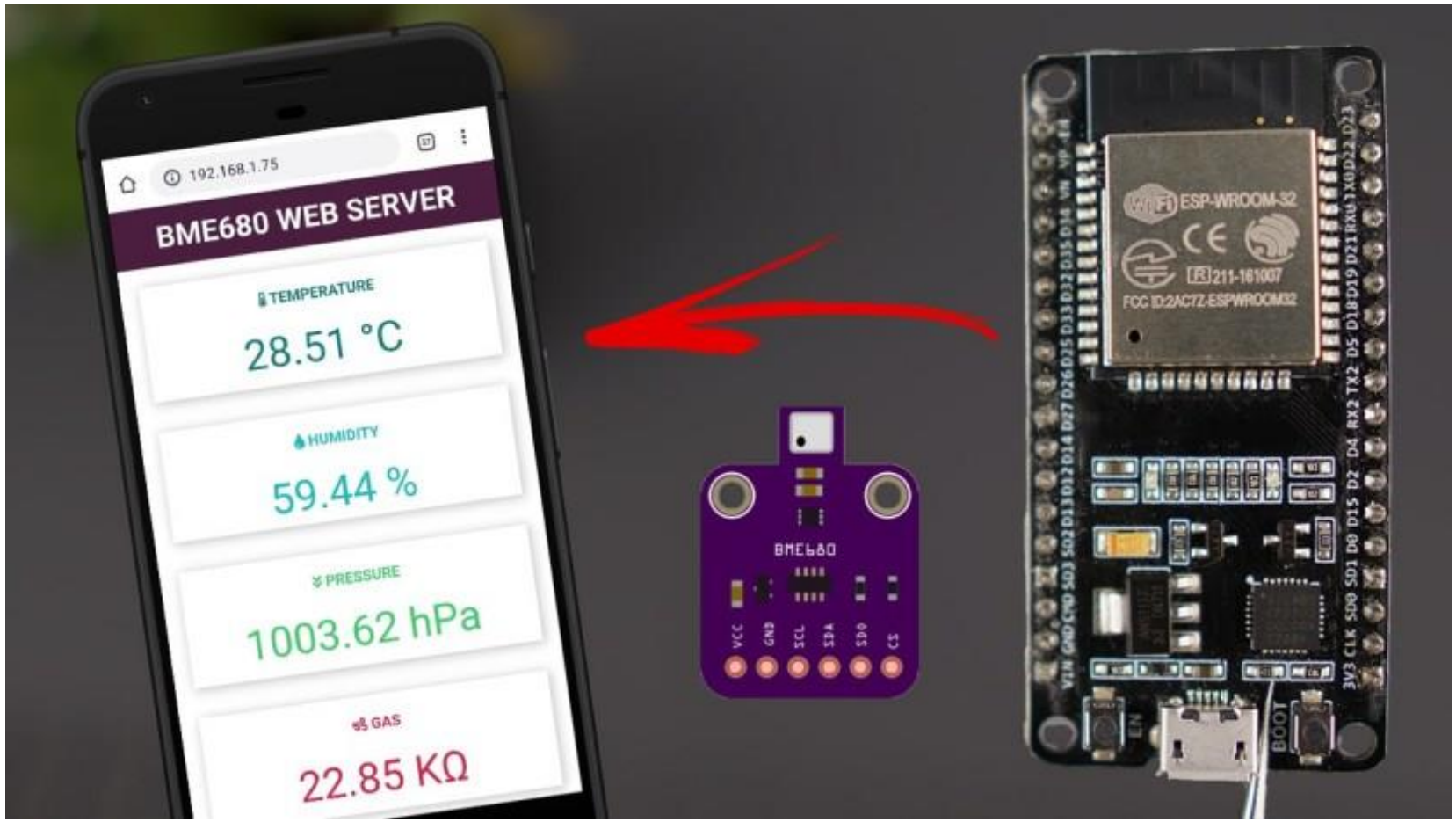
1. Analytical thinking and innovation
2. Active learning and learning strategies
3. Complex problem-solving
4. Critical thinking and analysis
5. Creativity, originality and initiative
6. Leadership and social influence
7. Technology use, monitoring and control
8. Technology design and programming
9. Resilience, stress tolerance and flexibility
10. Reasoning, problem-solving and ideation

Source: Future of Jobs Report 2020, World Economic Forum

Referensi

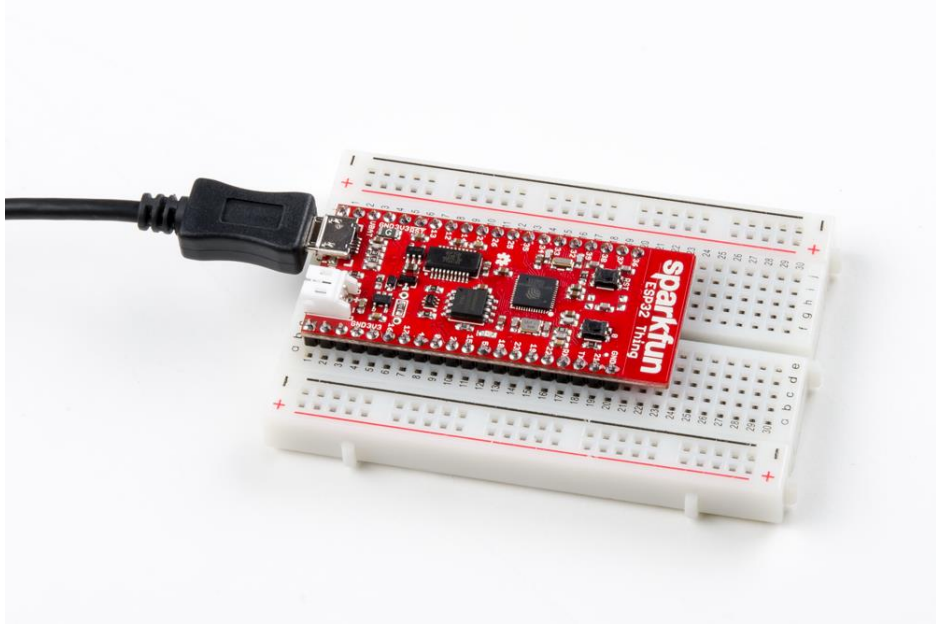
- Edward Asford Lee and Sanjit Arunkumar Seshia, Introduction to Embedded Systems, A Cyber-Physical Systems Approach, 2nd Edition, The MIT Press, 2017, https://mitpress.mit.edu/books/introduction-embedded-systems-second-edition
- Neil Cameron, Electronics Projects with the ESP8266 and ESP32: Building a Web Pages, Applications, and WiFi Enabled Devices, Apress, 2021, https://www.apress.com/gp/book/9781484263358
- Learn ESP32 with Arduino IDE, 2nd Edition, Course Tutorial https://randomnerdtutorials.com/learn-esp32-with-arduino-ide/
- Peter Marwedel, Embedded System Design 3rd edition, Springer 2018

Project: Web Server – Weather Station



Hardware Required

- ESP32 development board
- Micro USB Cable
- Breadboard, jumper cable
- Various resistors, LEDs, buttons, jumper cable
- Various displays
- Various sensors



List of Hardware Components

- ESP32 development board
- Bread board
- Jumper wires
- LEDs (Single color 5mm LEDs, RGB color)
- Assorted resistors (mostly 330 ohm and 10k ohm)
- 10k ohm photoresistors
- 10k ohm potentiometer
- Push button (breadboard-friendly momentary button)
- Piezo speaker
- BME 280 sensor
- DHT11/ DHT22 sensor
- DXL335 acceleration sensor board
- 16x2 LCD module with I2C backpack
- Seven segment display, common cathode
- Seven segment clock display with I2C
- 8x8 LED matrix display
- Small hobby DC motor
- DRV8871 motor controller
- 5V servo motor
- 470 uF kapasitor
- DS3231 real time clock module

Software required

- Text Editor (Notepad++, Kite, Atom, etc)
- The Arduino IDE https://www.arduino.cc/en/Main/Software
- Serial Terminal (optional)
  - Realterm (for Windows) https://sourceforge.net/projects/realterm/
  - Serial Tools (for MacOS) http://www.apphugs.com/serial-tools.html

Tools Required

- Soldering tools
- Multimeter
- Tweezers

Let’s create some fun ☺