About Things (Electronics)

ELEC-E9900 Networked Partnering and Product Innovation - NEPPI

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Learning Goals

- Learn to use reference designs
    1. to guide your design concept vision creation and
    2. to help you estimate the price of the needed components

What is a reference design?

- Reference design is a product that has as similar properties / functionalities with your intended product as possible

Ring-size - Oura

- https://ouraring.com/

- Weight: 4 to 6 grams
- Width: 7.9mm
- Thickness: 2.55mm

Sensors:

- Green LEDs (optical heart rate sensor)
- Red LED (blood oxygen sensor)
- Infrared Photoplethysmography (PPG) sensors
- Skin temperature sensors (negative temperature coefficient sensors)
- Photodiodes
- 3D Accelerometer

Connectivity:
Bluetooth Low-Energy (Bluetooth Smart®)

Battery & Power:
Up to 7 days of battery life

Ring-size - Oura

- https://ouraring.com/

Battery: Grepow curved LiPo ~10€
21mAh, 0.0777Wh

MCU: ~10€
Infineon PSoC 6 MCU: CY8C63x6
32-bit Dual CPU Subsystem
- 150-MHz Arm® Cortex®-M4F
- 100-MHz Cortex-M0+

Battery management: ~€1
Texas Instruments BQ25155

Titanium ring: ~2€

Sensors: ~2€
LEDs: ~0.2€
Other components: ~5€

Wrist band –size
Garmin Vívosmart 4

- https://www.garmin.com/en-US/p/782585#specs

- MCU: nRF51422, ~2€
- Capacitive touch: CY8C20247S, ~1€
- Battery: 70mAh, Li-Ion, ~3,5€
- Battery management: ~3€

Connectivity:
Bluetooth Smart®, ANT+®

Battery & Power:
Up to 7 days of battery life

Sensors

GARMIN ELEVATE™ WRIST HEART RATE MONITOR	✔
ACCELEROMETER	✔
AMBIENT LIGHT SENSOR	✔
PULSE OX BLOOD OXYGEN SATURATION MONITOR	✔

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Batteries Reference Prices

- Ring-size   curved, 20 mAh, ~10 €
- Wristband-size   50-70 mAh, ~3 €
- Watch-size   200-500 mAh, ~7 €
- Palm-size   1.4 Ah, ~7€
- Book-size   8 Ah, ~50 - 100? €

2021 MacBook Pro has 12 battery modules…

2021 16-inch MacBook Pro, 99.6 Wh battery (11.45 V, 8693 mAh)

Batteries from the 16" (top) and 14" (bottom) 2021 MacBook Pros. Click to enlarge

No batteries at all?

Shelly 1PM

CPU	RAM	Antenna	Overvoltage protection	Overpower protection
ESP8266	2MB	Flexible PCB	No	YES
Overtemp. ptotection	DC	AC	Bluetooth	Cloud + MQTT
YES	24-60V	110-240V	No	Separately
MQTT + SSL	UDP	Webhooks	User reset button	№ of parallel connections
No	Yes	HTTP	YES	2
Webhook limit per action	Scheduled webhooks	Scripting on device	Sunrise / Sunset actions	WiFi AP and Client mode
5	No	No	+/- 6h	Separately

Shelly Plus 1PM

CPU	RAM	Antenna	Overvoltage protection	Overpower protection
ESP32	4MB	Embeded Long distance	YES	YES
Overtemp. ptotection	DC	AC	Bluetooth	Cloud + MQTT
YES	24 - 30V	110 - 240V	YES	Simultaneously
MQTT + SSL	UDP	Webhooks	User reset button	№ of parallel connections
YES	RPC	HTTP & HTTPS	YES	10
Webhook limit per action	Scheduled webhooks	Scripting on device	Sunrise / Sunset actions	WiFi AP and Client mode
20	YES	YES	+/- 23h	Simultaneously
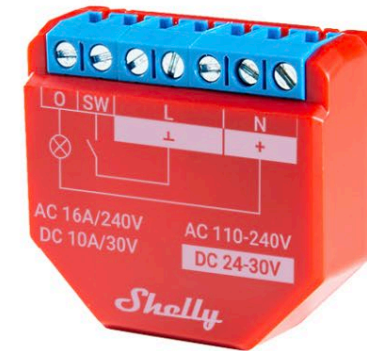
Computational capabilities

- Read a sensor and drive a servo   - Arduino UNO
- Display messages on small OLED screen   - ESP32
- Do real-time audio processing   - ESP32 (limited)
- Artificial Intelligence and Machine Learning - ESP32 (limited)

Typical electronic elements of an IoT product

- Battery (+battery management and charging)
- MCU (micro-controller unit)
- Sensor(s)
- Actuator(s)
- Printed Circuit Board (PCB) / wiring / components

How big a battery do we need?

- https://www.apple.com/watch/battery/
- 542 mAh battery

Aalto University

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MCU comparison table

- ATMega328 (Arduino UNO) ~2€
  - Speed 20 MHz, single core, 8 bit
  - Program Memory 32 KB, Data memory 1 KB

- ESP32 ~3€
  - Speed 240 MHz, dual-core, 32-bit
  - Program memory 520 KB, ROM 448 KB, Flash 16 MB

Meaningful differences in MCUs

- Processing capacity

- Memory

- Connectivity

- Inputs/Outputs

- Buses / Protocol support

Product elements

- Physical parts
    - Casing design
    - Mechanical designs

- Electronic parts

Prototype vs. Concept

- Design Concept represents the desirable future vision
  - It is a <u>management</u> tool
- Prototype represents what you want to learn
  - It is a <u>learning</u> tool
  - Prototype can also be used as a demonstrator as part of your concept presentation

What is required in NEPPI?

- Benchmark the key reference designs
  - Check if someone has done the product teardown of those products (e.g. on iFixit)
  - Check what are the main electronic components
    - MCU, battery, sensors, actuators, connectivity
  - Estimate the price tags
    - For you
    - For the customer