Electronique pour la conception des systèmes embarqués

4SE08-: Introduction

Chadi Jabbour

Année scolaire 2024-2025

What is an embedded system ?

An embedded system :

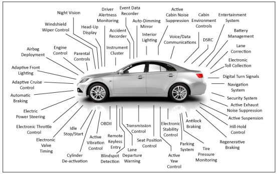
- is a computer based system
- is designed for a specific function or for several specific functions
- is embedded in a larger mechanical or electrical system
- is driven by and must respond to real world events

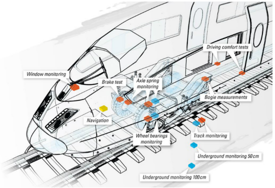
What is an embedded system ?

Focus of the course

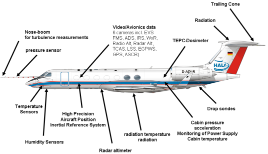
An embedded system is driven by and must respond to real world events

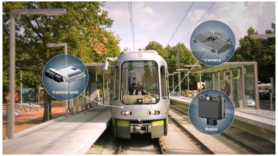
Transport





Basic sensors and data Acquisition
Integration and Operation: DLR-FB

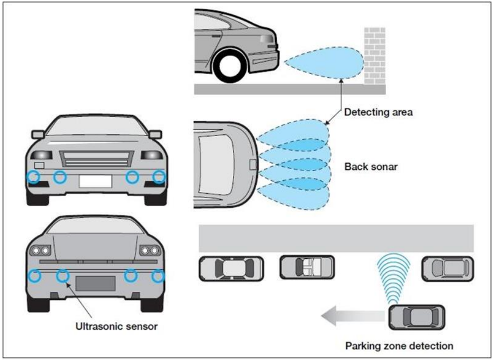




Increasing number of electronic devices in transport

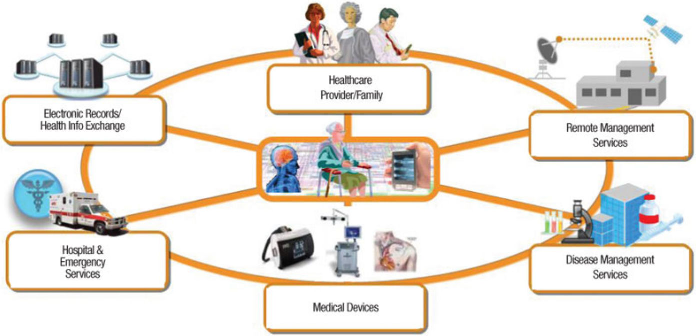
TELECOM Paris

Example : Assisted Parking system



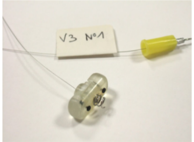
Parking systems use ultrasonic sensors to calculate the distance between the car and the obstacles

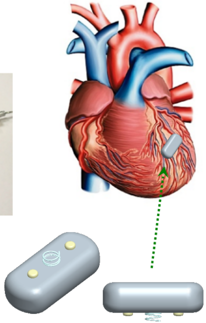
Health



Electronic systems are massively used in medical applications today and this trend will accelerate in the near future

Example : Cardiac implant

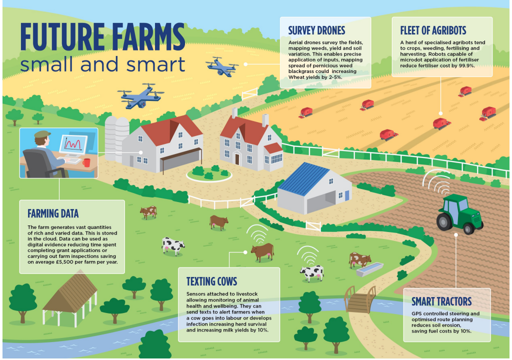


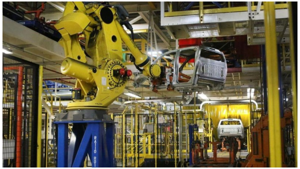


Collaboration TP-MicroportCRM

Design of several communcating cardiac sensors to help the operation of the pacemaker

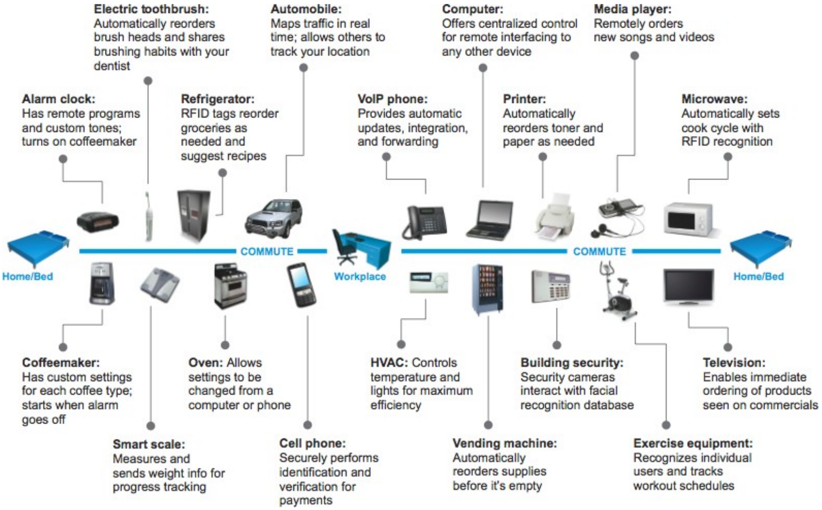
Professional applications



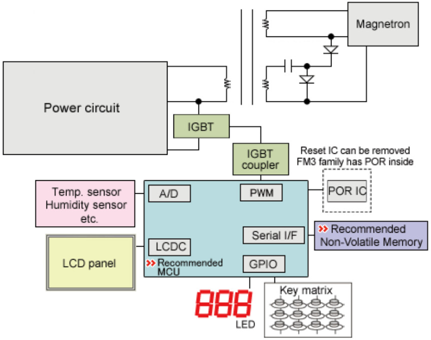


Embedded systems are widely used for improving the production in professional applications such as Industry, Agriculture & Construction

Consumer electronics and Appliances



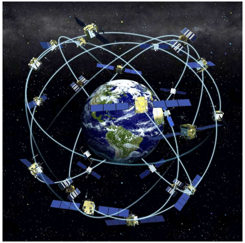
Example : Microwave



Microwave emebedded system

Even in a simple microwave, the electronic circuitry is somehow complex with a high number of interfaces.

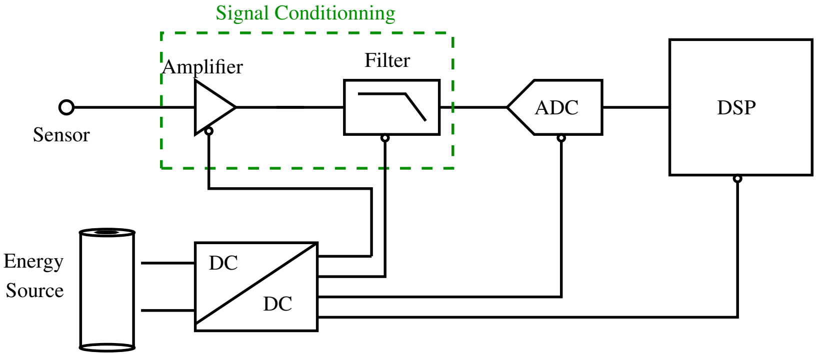
Aerospace



Despite the small volume, embedded systems for aerospace are highly needed and various :

- Launchers
- Communications and observations satellites
- Rovers

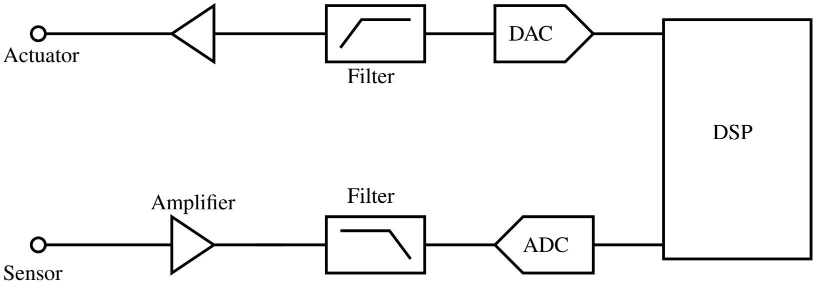
Interface with the real world



Sensors

- Antennas
- Accelerometer
- Ultra-sound sensor
- Temperature sensors
- Humidity sensor
- Magnetic field sensors (Hall effect ...)
- Photodiode (Camera)
- Tactile sensor
- Proximity sensor
- ...

Interface with the real world in both directions

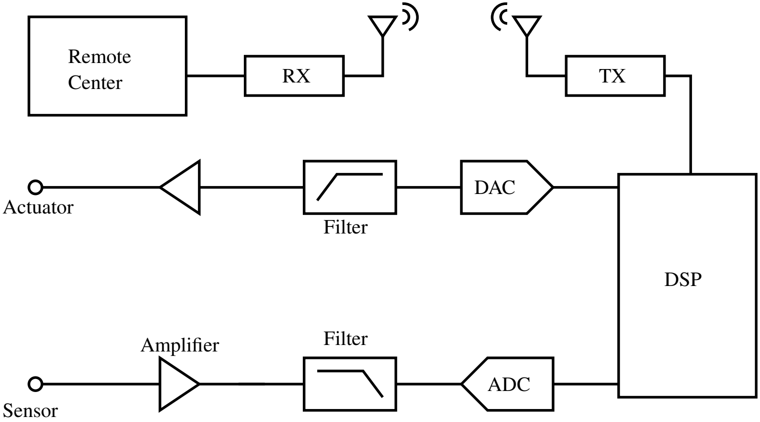


Embedded systems also need often to interact back with the real world

Actuators and Co.

- Antenna
- Electrical/electronic switch
- Motor
- Ultra-sound sensor
- Controlled valve
- Screen
- Speaker
- Connected door lock
- Pulse generator
- ...

Embedded systems with remote centers/gateways



In some applications, information need to reported to a remote center

Transmission Protocols

TELECOM Paris

Transmission Protocols comparison

basvankaam.com sharing knowledge

The Internet of Things networking technology cheat sheet 1.0

Network:	Sigfox	LoRa	NB-IoT (Cat NB1)	LTE-M (Cat M1)	LTE Cat 0	LTE Cat 1
Type:	PLWAN	PLWAN	DSSS modulation	LTE (cellular)	LTE (cellular)	LTE (cellular)
Low Power:	+++++	++++	++++	+++	++	++
Throughput Kbit/s:	0,1	50	100	375	1000	10.000
Bandwidth:	Ultra-narrowband	Narrowband	Narrowband	Low	High	High
Latency:	1 – 30s	Based on profile	1.6 – 10s	10 – 15ms	Unknown	50 – 100ms
Standard:	Proprietary	Proprietary	3GPP Rel. 13	3GPP Rel. 13	3GPP Rel. 12	3GPP Rel. 8
Availability world-wide:	++	+++	++	++	+++++	++++
Spectrum:	Unlicensed ISM	Unlicensed ISM	Licensed LTE	Licensed LTE	Licensed LTE	Licensed LTE
Complexity:	Very low	Low	Very low	Low / medium	High	High
Coverage / range:	Medium / high	Medium / high	High	High	High	High
Battery life:	Very high	Very high / high	High	Medium / high	Low	Low
Gateway needed:	Yes	Yes	No, but optional	Optional	Optional	Optional
Signal penetration:	High	Medium / high	Medium / high	Medium / high	Low	Low
Security:	+++	+++	+++	+++++	++++	++++
Future proof:	+++	+++	+++++	+++++	+++	+++

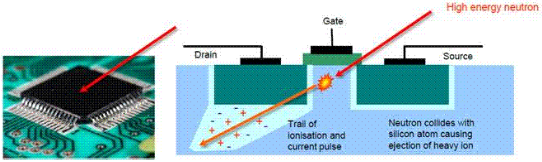
See the accompanying blog series on basvankaam.com for more details on some of the abovementioned features/characteristics

Saturday, July 15, 2017 - Twitter @BasvanKaam

Constraints

- Cost $$$$$
- Power consumption
- Security
- Dependability/Safety
- Miniaturization
- Mechanical vibrations
- Thermal variations
- Radiations
- Medical compatibility
- ...

Radiations : how does they impact the system



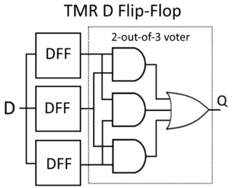
- Circuits are sensitive to radiations
  - Cosmic rays
  - Solar wind
  - Nuclear reactors and explosions

- Radiation can result in :
  - Short term dis-functionality
  - Loss of performance (Lower gain, higher leakage current ...)
  - Permanent damage of the radiated area

Radiations : Hardening techniques

- Physical hardening
  - Shielding the package against radioactivity
  - Use of radiation robust technology

- Hardening by design
  - Take design margin to anticipate the loss of performance - analog circuits
  - Triple modular redundancy for critical functions - digital circuits



Temperature variations : how does they impact the system

When the temperature increases,

- the component (transistor, resistors) noise gets higher (approx. proportional to the temperature in Kelvin)
- the product lifetime gets lower
- the system becomes slower

Solutions :

- Employ a cooling/heating system to ensure that the embedded circuit is always inside the good temperature range
- Tackle the problem by design. For example, adjust the supply voltage or the biasing currents with the temperature variations
- Use a dedicated technology

Battery life

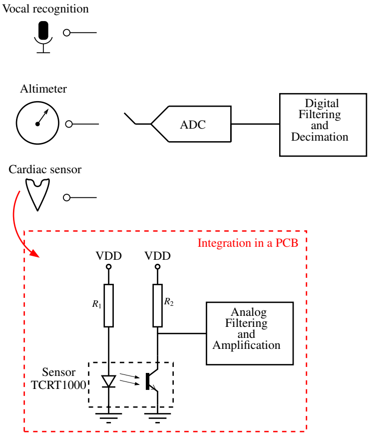
- Reduce power consumption (avoid over sizing, good design ...)
- Reduce energy consumption (duty-cycling, clever approaches at protocol level ...)
- Optimized partitioning between node and cloud
- Energy Harvesting
- ...

Course organization - connected watch

Heart sensor for a connected watch :

-Analytical study
-Electrical simulation
-PCB design and fabrication
-Acquisition with an ADC
-Digital processing

Used tools :
-Octave
-LTspice
-Kicad
-Micropython
-Matlab



Course organization

- Introduction and prerequisite - Course 1 hour - Chadi Jabbour
- Analog to digital converters - Course 1 hour - Chadi Jabbour
- Raspberry Pi ADC - Lab 1 hour - Chadi Jabbour
- Power supplies - Course 1.5 hours - Reda Mohellebi
- PCB design - Course 1.5 hours - Reda Mohellebi
- Elec. Simulators on LTspice - Lab/Course - 3 hours - C. Jabbour/C. Mohelebbi
- PCB design with Kicad - Lab/Course - 3 hours - R. Mohelebbi/C. Jabbour (10 %)
- Digital Filtering - Course/TD - 3 hours - Chadi Jabbour
- Energy Harvesting - Course/TD - 1.5 hours - Germain Pham
- PCB Fabrication / Verification - Course- 1.5 hours - Reda, Chadi & Karim
- Signal Acquisition - Lab - 3 hours - Chadi Jabbour/Reda Mohellebi (20 %)
- Digital Filtering implementation - Lab - 1.5 hour - Chadi Jabbour (10 %)
- Final exam (60%)

This is the end

Thank you for your attention

Questions ?