MagoNode:
a new mote for Wireless Sensor Network

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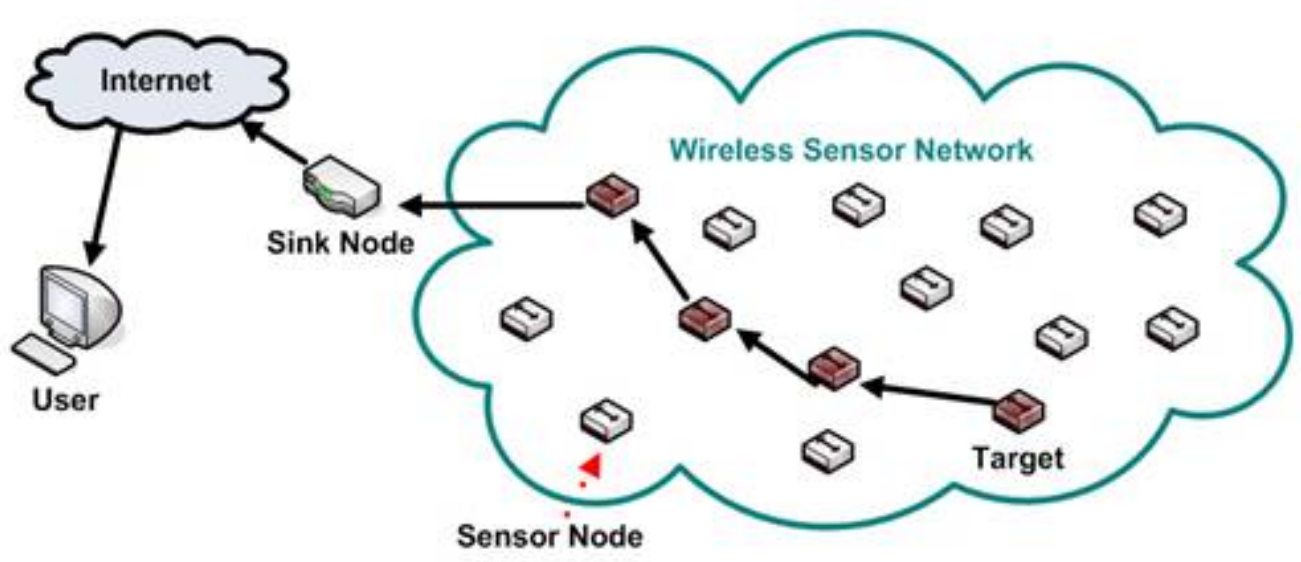
Wireless Sensor Networks: scope

A wireless sensor network (WSN) consists of sensor nodes able to monitor physical or environmental conditions

Scope:

- Collect information from the surrounding environment
- Pass it through the network to a main location (sink)



Wireless Sensor Nodes: features

- Battery fueled
- Wireless communication
- Sensors and/or actuators
- Limited computational & memory capabilities
- Small sizes

Main bottle neck

The lifetime of a mote is constrained by the limited amount of energy available

Wireless Sensor Nodes: hardware

- Microcontroller Unit (MCU)
  - CPU
  - RAM
  - ROM
  - Other peripherals and interfaces
- Radio Transceiver
  - 2.4 GHz
  - 868 MHz (EU)
- Sensors (analog or digital)
  - Light
  - Temperature
  - Humidity

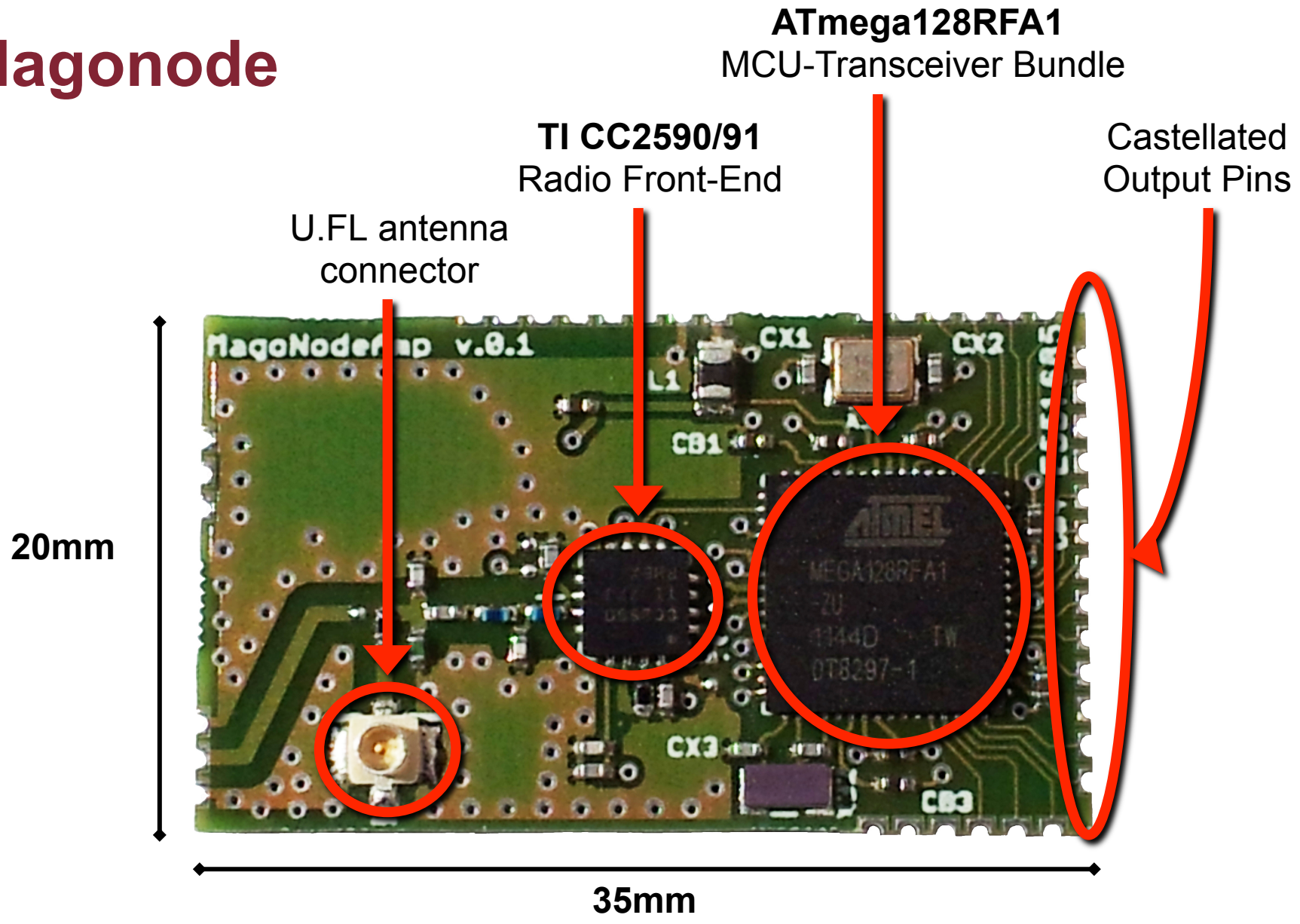
Motivations

Own HW Platform vs Proprietary HW platform:

- project & design
- assembly → dedicated machines & lab tools
- time & knowledge

+ fully customizable
+ full control of the hardware platform
+ easy to interface external hardware (modularity)
+ a deep knowledge of the HW ease the development of SW

Magonode


ATmega128RFA1
MCU-Transceiver Bundle
TI CC2590/91
Radio Front-End
Castellated
Output Pins
U.FL antenna
connector
20mm
35mm

ATmega128RFA1

Main Features:

- *High Performance, Low Power AVR 8-bit Microcontroller, 16MHz*

- *Fully integrated Low Power Transceiver for 2.4 GHz ISM Band*
  - Supported Data Rates: 250 kb/s, 500 kb/s, 1 Mb/s, 2 Mb/s
  - 100 dBm RX Sensitivity; TX Output Power up to 3.5 dBm

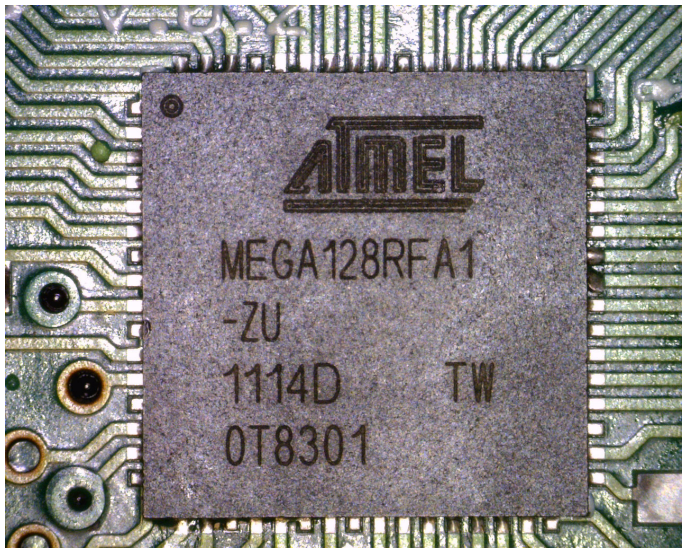
- *Ultra Low Power consumption*
  - CPU Active Mode (16MHz): 4.1 mA
  - 2.4GHz Transceiver: RX 12.5 mA / TX 14.5 mA
  - Deep Sleep Mode: <250nA

- *Non-volatile Program and Data Memories*
  - 128K Bytes of In-System Self-Programmable Flash
  - 4K Bytes EEPROM
  - 16K Bytes Internal SRAM

ATmega128RFA1

Peripheral Features:

- 10-bit, 330 ks/s ADC
- JTAG interface
- SPI Serial Interface
- Two USART
- I2C interface
- Watchdog Timer



External Hardware Requirements:

- 32.768 kHz OX → RTC, Low Power Modes
- 16 MHz OX → Radio Operations
- Balun for antenna impedance matching

RF Front-end

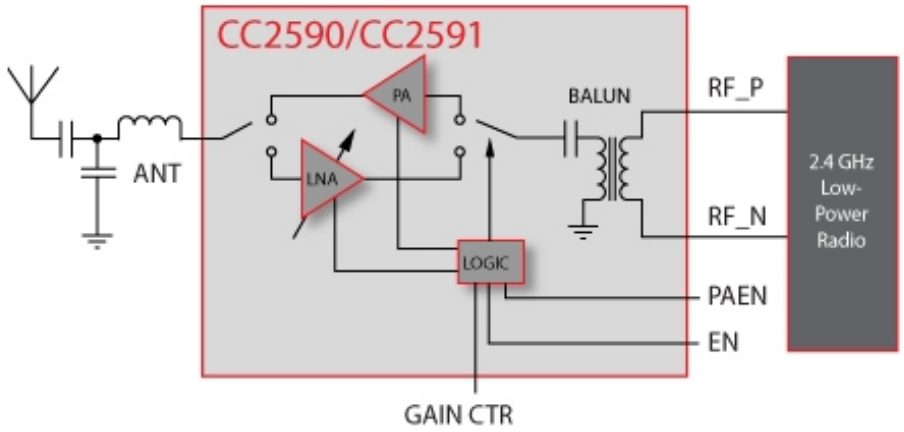
An RF Front-end embeds:

- a low noise amplifier (LNA) to improve the receiver sensitivity
- a power amplifier (PA) to increase the output power

Pros & Cons:

+ overwhelms weaknesses of 2.4GHz band
+ extends radio range of a mote
+ increases channels reliability
- energy overhead

TI CC2590 / TI CC2591



Interchangeable 2.4GHz ISM band Front-ends:

CC2590 → power output up to +14dBm → taylored for EU market

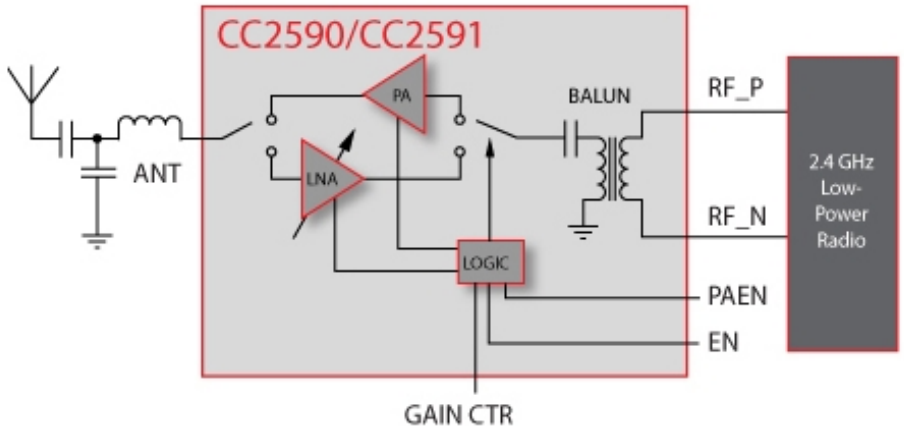
CC2591 → power output up to +22dBm → taylored for US market

TX consumptions:

CC2590 → 22mA @ 3V for +12dBm, PAE = 23%

CC2591 → 100mA @ 3V for +20dBm Out, PAE = 33%

TI CC2590 / TI CC2591



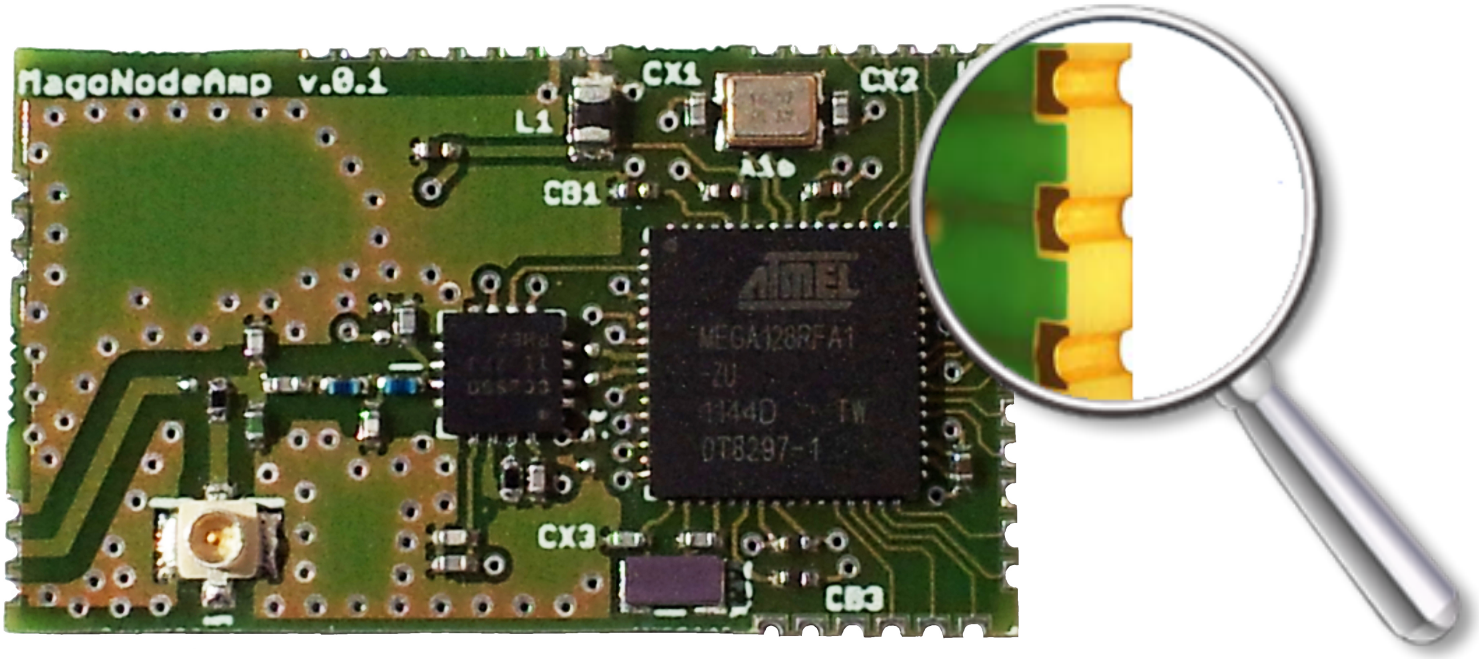
Common features:

- 6dB Typical Improved Sensitivity (RX)
- 100nA in Power Down
- 4.6dB LNA Noise Figure
- Integrated Matching Network, Balun, Inductors
- QFN-16 Package
- 2.0V to 3.6V Operation
- RX consumptions:
  - 3.4mA for High Gain Mode
  - 1.8mA for Low Gain Mode

PCB & RF design

4-Layer design OEM board:

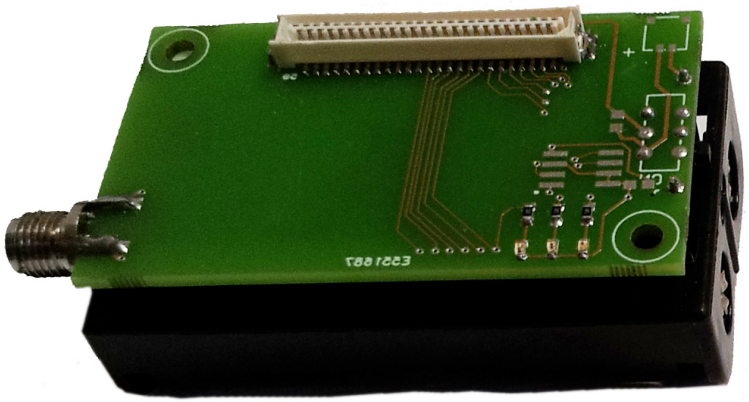
- *Castellated PCB* → easily solderable on expansion boards
- *RF filtering section* → to ensure a good impedance matching



Expansion Modules 1/3

MNA-Board:

- academic-like board
- 2xAA battery holder
- Power switch
- 3 debug leds
- RP-SMA
- 51 pin Hirose expansion connector
- 2MB flash chip (optional)
- Dimensions: 32mm x 55mm

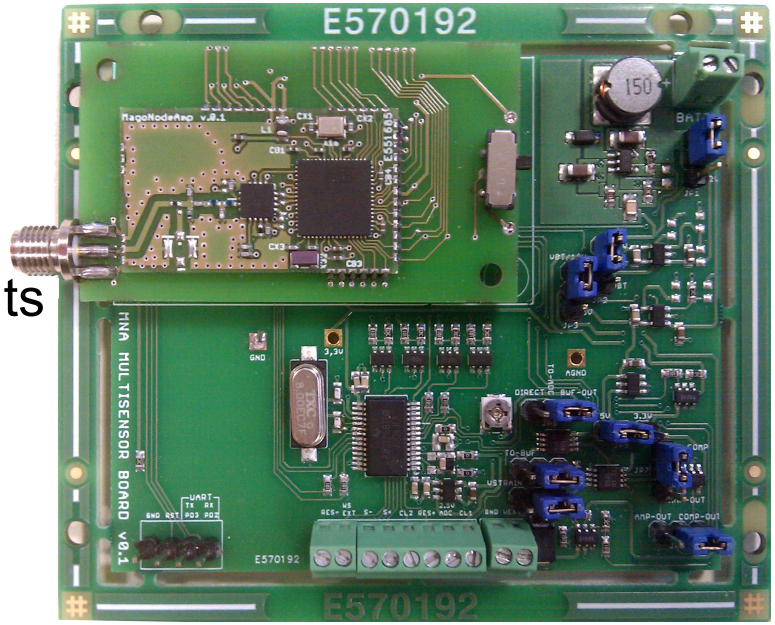


It allows quick prototyping and debugging as much as easy deployment.

Expansion Modules 2/3

The Multi-Sensor Board is able to interface a great variety of analog sensors. It features:

- TI ADS1256 ADC
  - 24 bits
  - Data output rate up to 30kSPS
  - 4 Differential / 8 Single-Ended Inputs
  - SPI interface
- TI LMR62014 Boost converter
- 3.3V & 5V voltage regulators



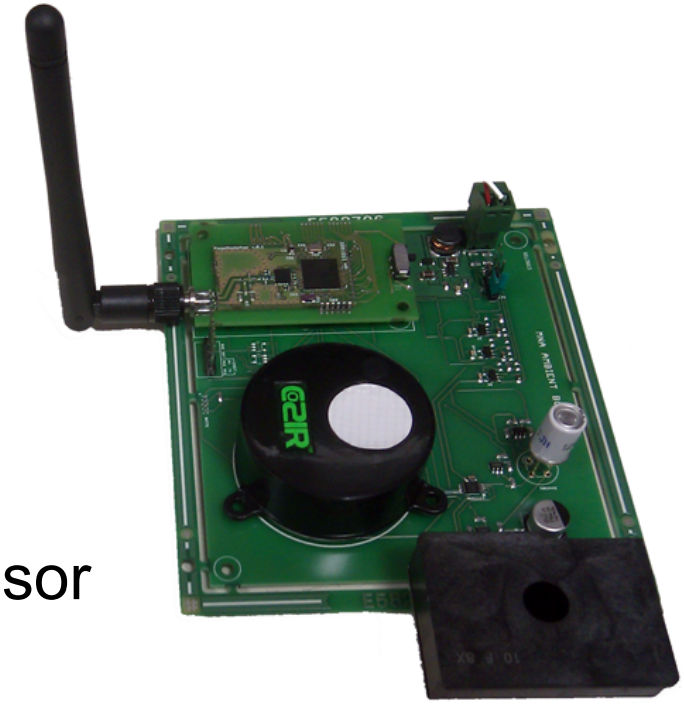
Interfaceable Sensors Types:

- 4-20mA Current Loop
- Strain Gauge
- Potentiometer
- Resistive
- Weight Scale

Expansion Modules 3/3

The Ambient Board features digital and analog ambient sensors:

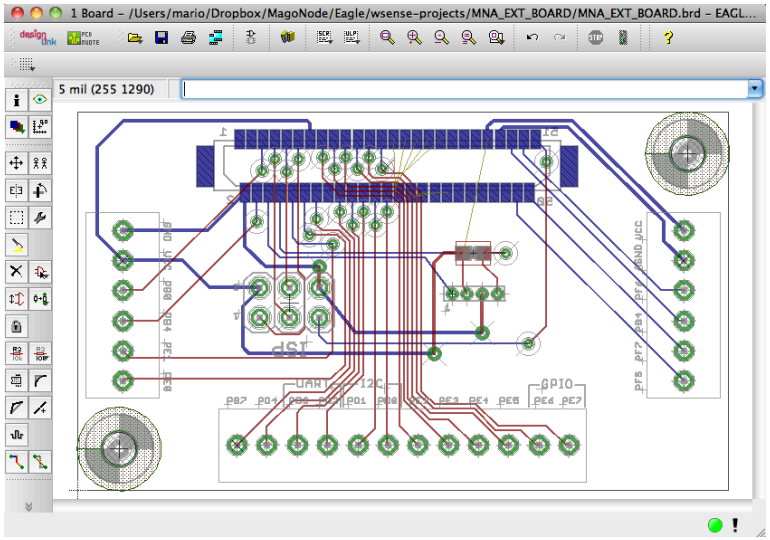
- CO Sensor
  - Figaro TGS2442
- CO2 Sensor
  - Co2Meter CO2IR
- Dust Sensor
  - Sharp GP2Y1010AU0F
- Temperature and Humidity sensor
  - Sensirion SHT75



Productive process: PCB design & print

PCBs are designed using EAGLE cad software

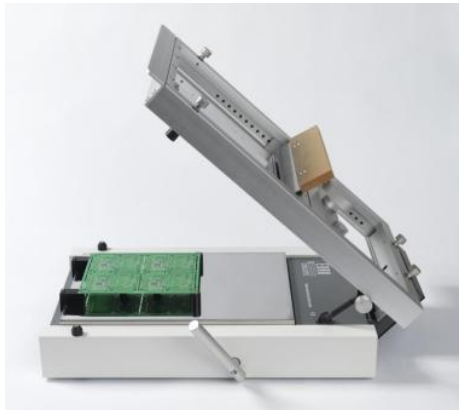
- Schematic Editor
- Board Layout Editor
- Errors Check and Corrections
- Gerber Files creations
- Lots of Libraries



PCBs printing is subcontracted to a circuit manufacturing company

Productive process: assembly

1. **Apply the solder paste using a stencil**

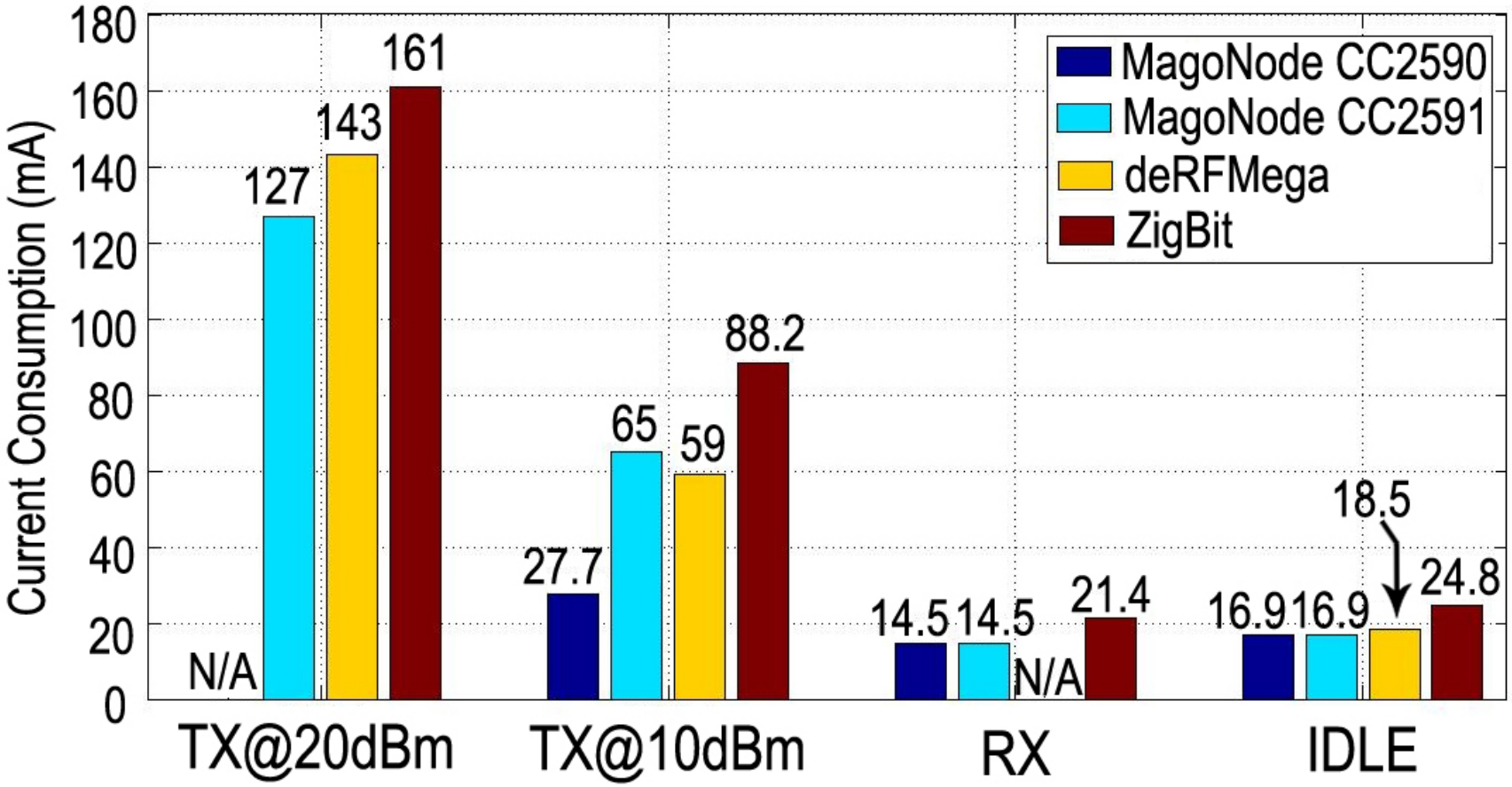


2. **Place components on the board**

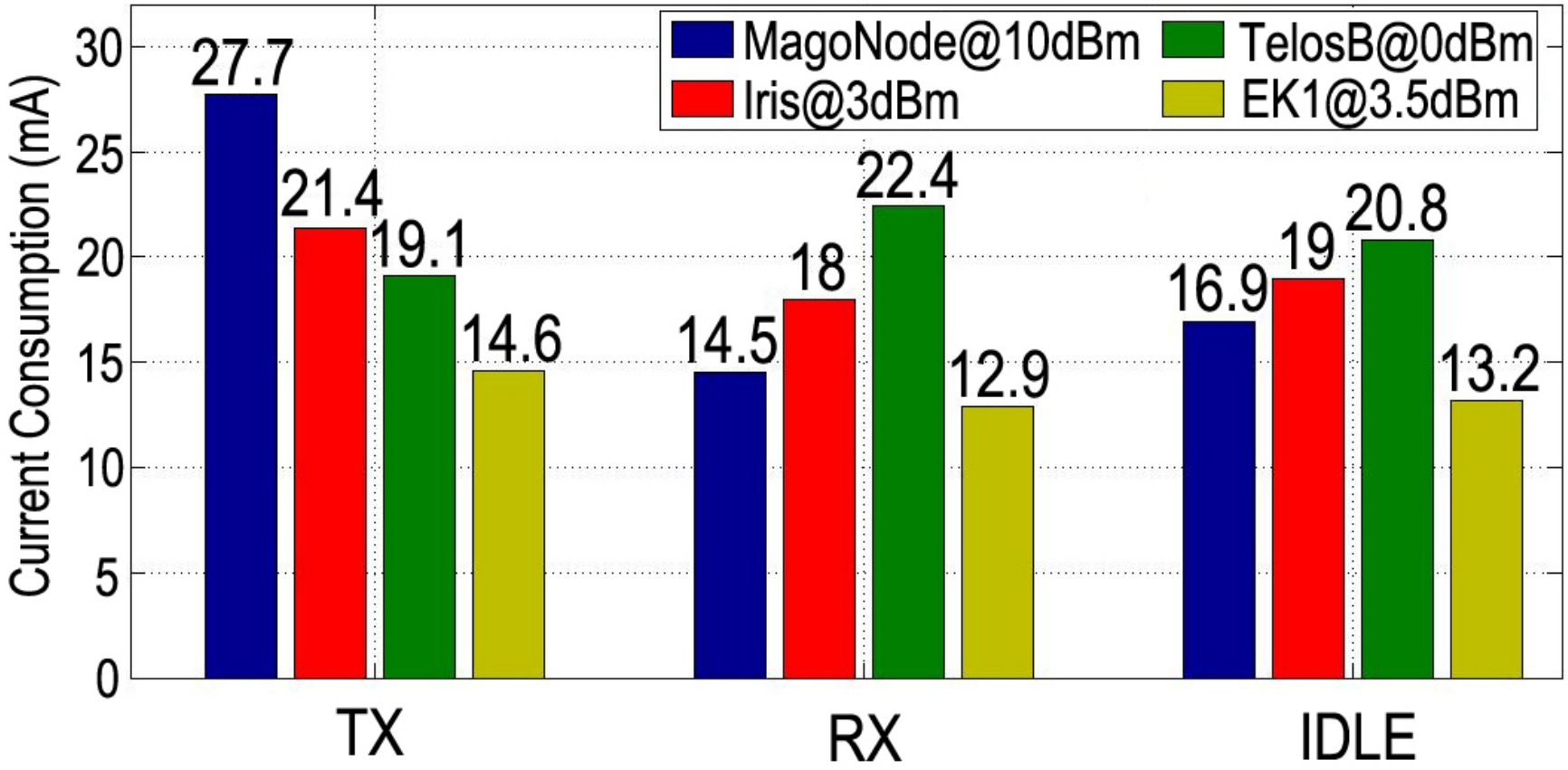
3. **Put the Board in the Reflow Oven**

4. **Rework with the Iron Solder if needed**

Consumptions: Amp Motes Comparison



Consumptions: Motes Comparison



TinyOS

The MagoNode is compatible with TinyOS:

- It is a open-source OS dedicated to embedded systems
- Open-source ➔
  - Source code easily reusable
  - Large developers community
- It supports for a great variety of hardware modules

Protocol stacks:

- **CTP+LPL**: Default Routing and MAC layers implemented in TinyOS
- **DISSense:** is an adaptive, cross-layer ultralow-power communication protocol for wireless sensor networks.
- **802.15.4e:** defines a MAC protocol based on Time Slotted Channel Hopping (TSCH).