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

MagoNode: a new mote for WSN
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

MagoNode: a new mote for WSN
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 → tailored for EU market  
**CC2591** → power output up to +22dBm → tailored for US market

TX consumptions:

**CC2590** → 22mA @ 3V for +12dBm, PAE = 23%  
**CC2591** → 100mA @ 3V for +20dBm Out, PAE = 33%

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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.
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

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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

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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

- **MagoNode CC2590**
- **MagoNode CC2591**
- **deRFMega**
- **ZigBit**

<table>
<thead>
<tr>
<th>State</th>
<th>MagoNode CC2590</th>
<th>MagoNode CC2591</th>
<th>deRFMega</th>
<th>ZigBit</th>
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<td>TX@20dBm</td>
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<td>161</td>
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<td>18.5</td>
<td>24.8</td>
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Consumptions: Motes Comparison

MagoNode: a new mote for WSN
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).