



# Radiation monitoring system based on the prototype open source electronic platform



Andrea Chanoux – Arpa Piemonte

# Arduilly

- What's Arduilly?
  - it's a circuit that listens to the FM radio broadcasters (88-108 MHz)
  - recognizes the names of the channels/broadcasters
  - verifies if something changes
- How it's made Arduilly?
  - it's a radio tuner
  - it's based to Arduino board
  - it's equipped with a solar pannel for the power supply





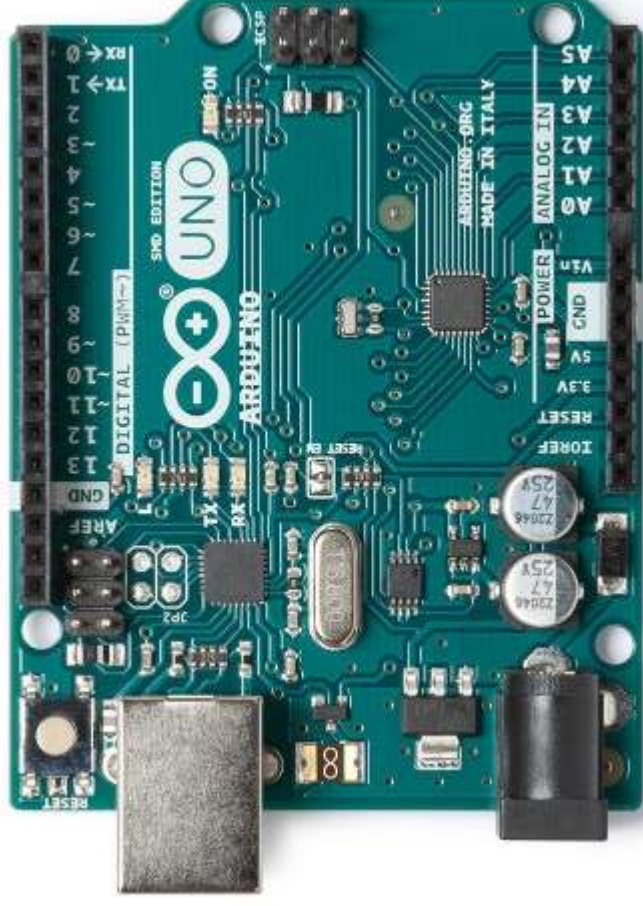
# Why Arduilly?

- We needed a system to control the FM radio broadcasters of the site named “Maddalena” :
  - Did they change the radio frequency?
  - Did they switch off some channel?
  - Is there any new radio broadcaster on air?
- We wanted a circuit that we can customize :
  - We have discovered the ARDUINO board





# ARDUINO



What is Arduino?

Arduino is an open-source electronics platform based on easy-to-use hardware and software.

**hardware + software**  **open-source**

# From the website of Arduino ([www.arduino.cc](http://www.arduino.cc)):



HOME STORE SOFTWARE EDU RESOURCES COMMUNITY HELP



## What is Arduino?

Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino boards are able to read inputs - light on a sensor, a finger on a button, or a Twitter message - and turn it into an output - activating a motor, turning on an LED, publishing something online. You can tell your board what to do by sending a set of instructions to the microcontroller on the board. To do so you use the [Arduino programming language](#) (based on Wiring), and the [Arduino Software \(IDE\)](#), based on Processing.

Over the years Arduino has been the brain of thousands of projects, from everyday objects to complex scientific instruments. A worldwide community of makers - students, hobbyists, artists, programmers, and professionals - has gathered around this open-source platform, their contributions have added up to an incredible amount of [accessible knowledge](#) that can be of great help to novices and experts alike.

Arduino was born at the Ivrea Interaction Design Institute as an easy tool for fast prototyping, aimed at students without a background in electronics and programming. As soon as it reached a wider community, the Arduino board started changing to adapt to new needs and challenges, differentiating its offer from simple 8-bit boards to products for IoT applications, wearable, 3D printing, and embedded environments. All Arduino boards are completely open-source,



# ARDUINO PCB + SHIELDS

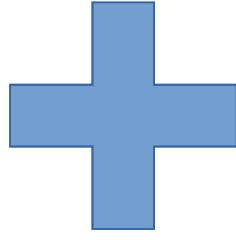
SOME TYPES OF SHIELDS



Ethernet Shield



ARDUINO PCB

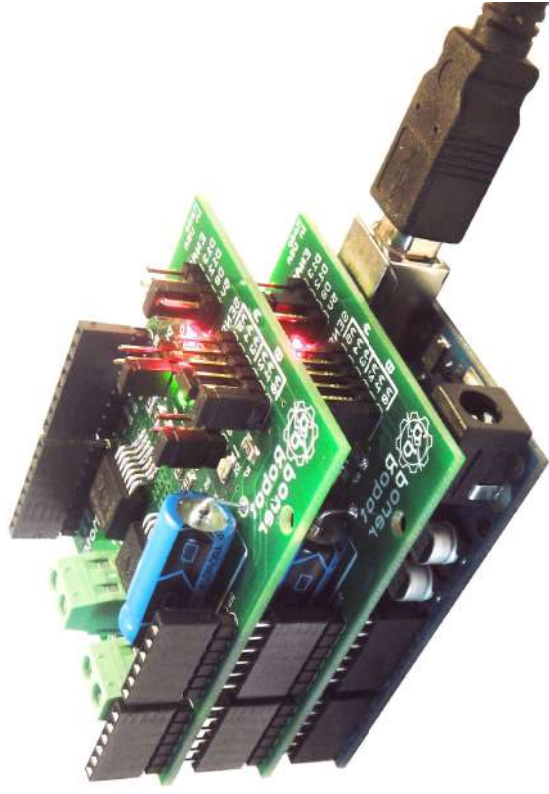


GPS shield



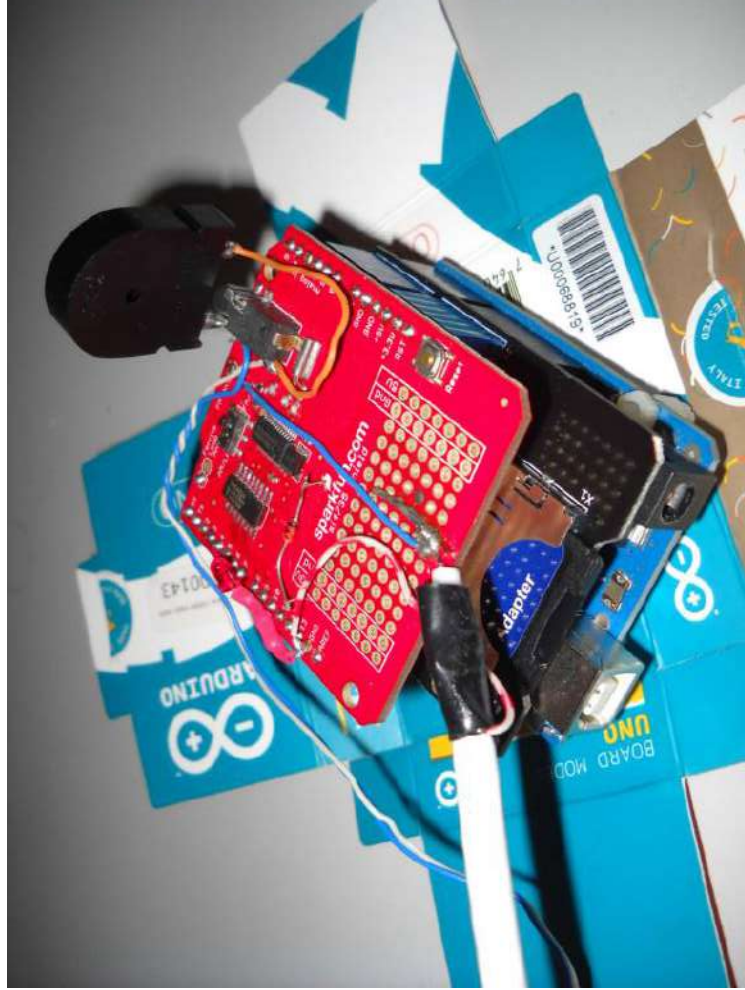
driver module for motors

Shields are boards that can be plugged on top of the Arduino PCB (Printed Circuit Board) extending its capabilities.

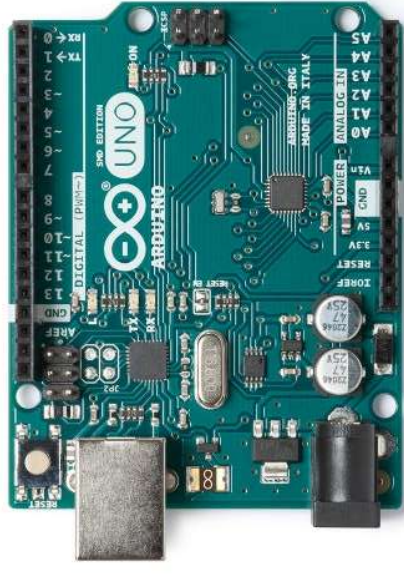




# My first Arduilly



ARDUINO UNO BOARD



FM RADIO TUNER BOARD si4735

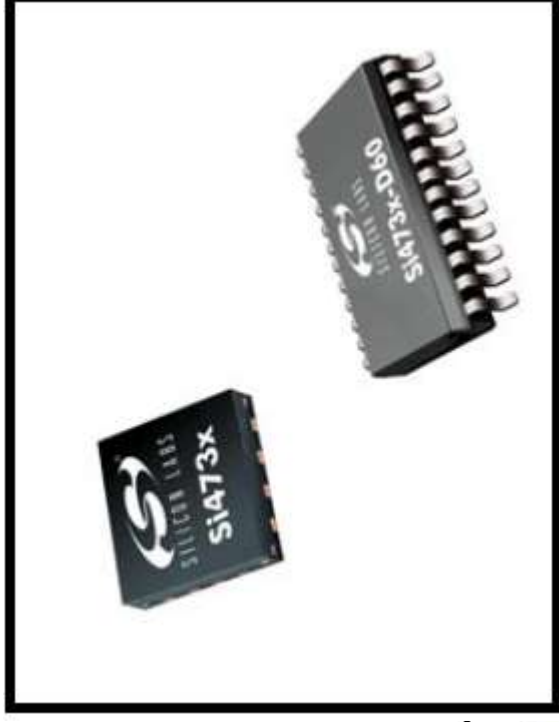




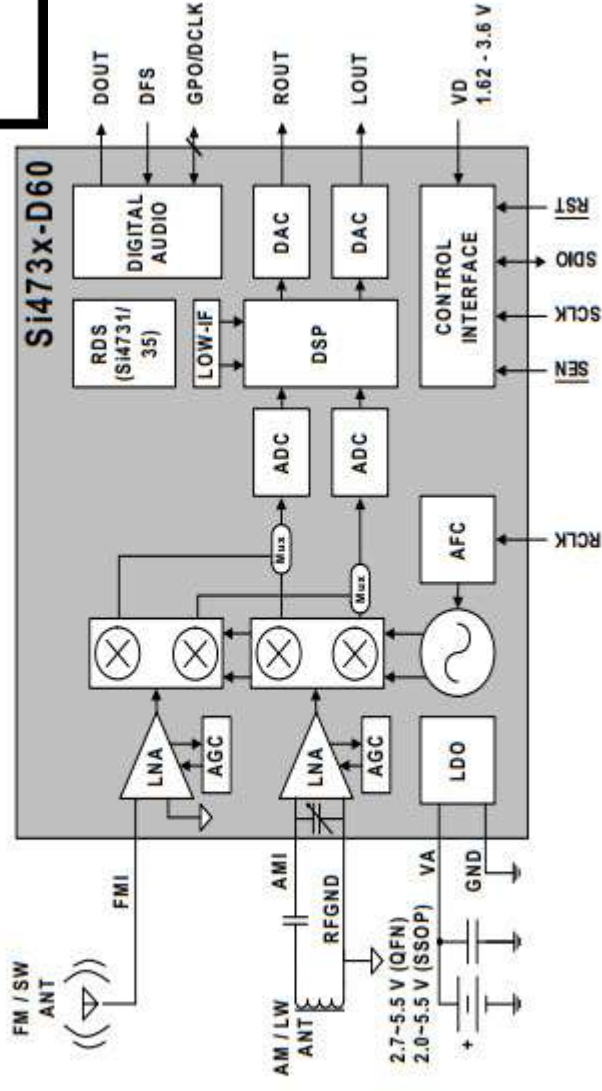


# RADIO FM SHIELD

- It's based on the Silicon Labs Si4735 radio tuner

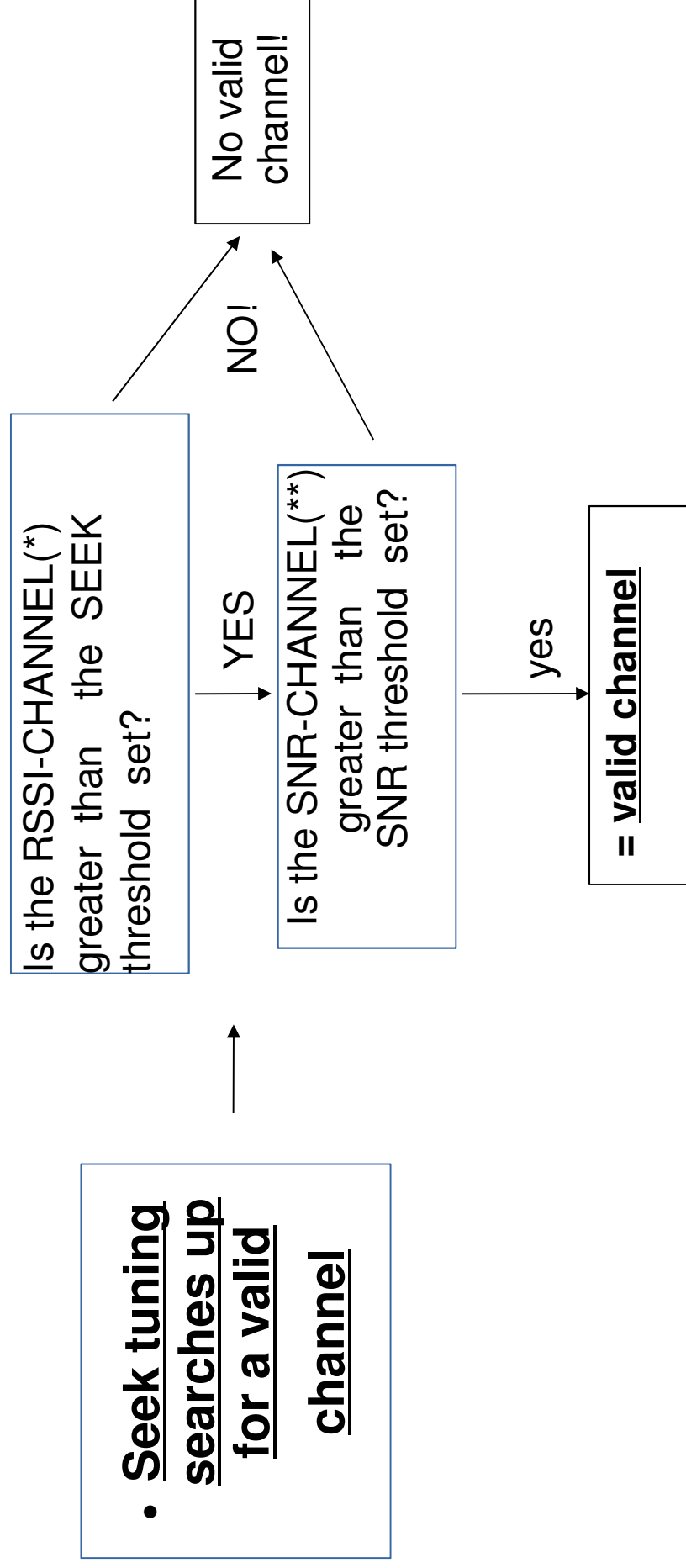


Functional Block Diagram





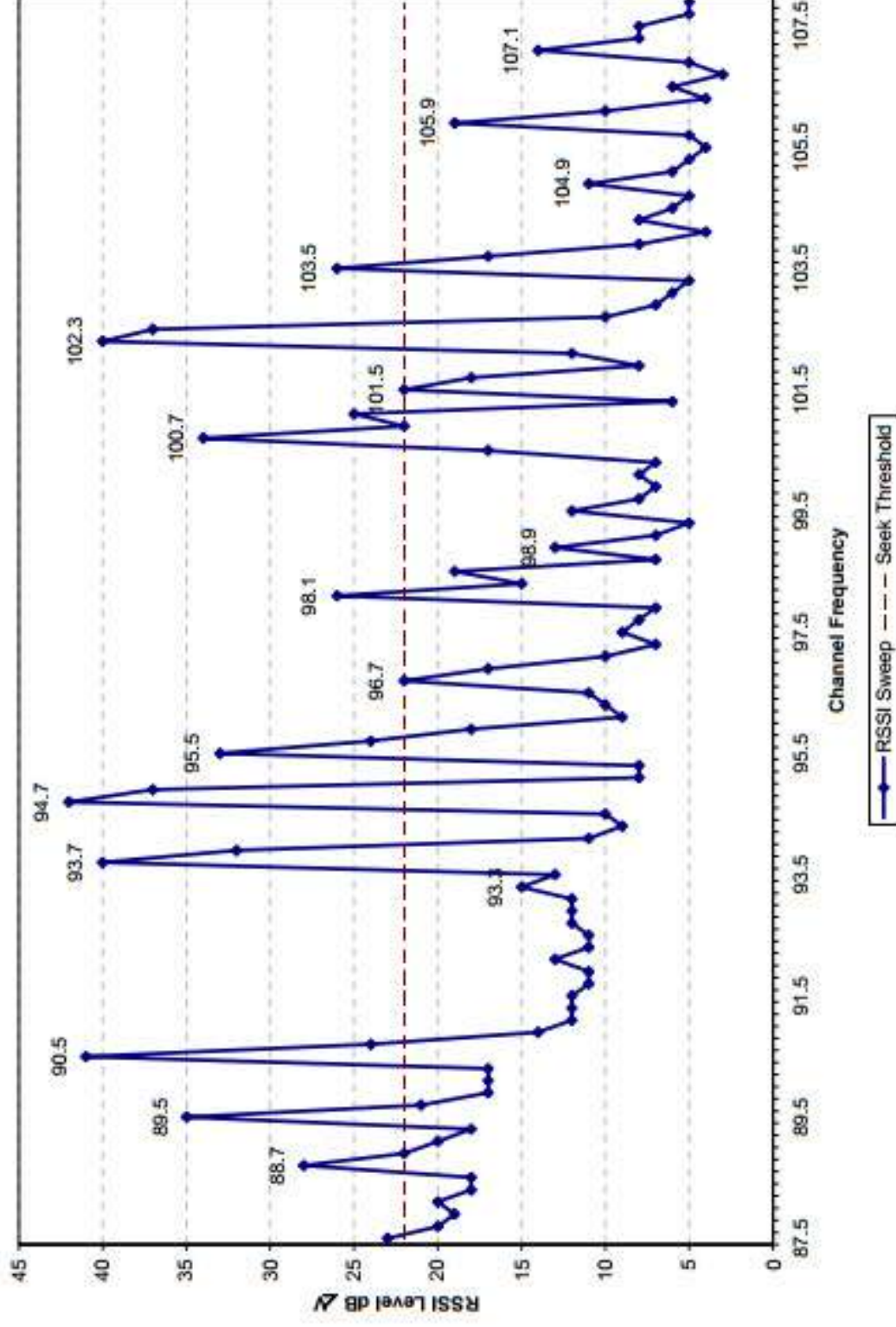
# How the 4735 find the valid stations?



- (\*) received signal strength indicator
- (\*\*) the signal-to-noise ratio



# How works the RSSI threshold





## FROM THE Si4735 DATASHEETS:

[...] The device offers significant programmability, and caters to the subjective nature of FM listeners and variable FM broadcast environments world-wide through a simplified programming interface and mature functionality. The Si4703-C incorporates a digital processor for the European Radio Data System (RDS) and the US Radio Broadcast Data System (RBDS) including all required symbol decoding, block synchronization, error detection, and error correction functions. RDS enables data such as station identification and song name to be displayed to the user[...]

The receive (RX) section integrates a low noise amplifier (LNA) supporting the worldwide FM broadcast band (76 to 108 MHz). An automatic gain control (AGC) circuit controls the gain of the LNA to optimize sensitivity and rejection of strong interferers. For testing purposes, the AGC can be disabled with the AGCD bit.[...]

Seek tuning searches up or down for a channel with an RSSI greater than or equal to the seek threshold set with the SEEKTH[7:0] bits. In addition, optional SNR and/or impulse noise detector criteria may be used to qualify valid stations. The SKSNR[3:0] bits set the SNR threshold required. [...] Using the extra seek qualifiers can reduce false stops and, in combination with lowering the RSSI seek threshold, increase the number of found stations.[...]

Two-wire slave-transceiver and three-wire interfaces are provided for the controller IC to read and write the control registers.

# REGISTER CONFIGURATION

## 5. Register Summary

Reg <sup>1</sup>	Name	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0		
00h	DEVICEID	MFGID[11:0]																	
01h	CHIPID	REV[5:0] PNI[3:0] DEV[3:0] FIRMWARE[5:0]																	
02h	POWERCFG	DSMUTE	DMUTE	MONO	0	RDSM <sup>2</sup>	SKMODE	SEEKUP	SEEK	0	DISABLE	0	0	0	0	0	ENABLE		
03h	CHANNEL	TUNE	0	0	0	0	CHAN[9:0]												
04h	SYSCONFIG1	RDSIEN <sup>2</sup>	STCIEN	0	RDS <sup>2</sup>	DE	AGCD	0	0	BLNDADJ[1:0]	GPIO3[1:0]	GPIO2[1:0]	GPIO1[1:0]						
05h	SYSCONFIG2	SEEKTH[7:0] BAND[1:0] SPACE[1:0] VOLUME[3:0]																	
06h	SYSCONFIG3	SMUTER[1:0]	SMUTEA[1:0]	0													VOLEXT	SKSNR[3:0]	SKCNT[3:0]
07h	TEST1	XOSCEN	AHIZEN																
08h	TEST2																		
08h	BOOTCONFIG																		
0Ah	STATUSRSSI	RDSR <sup>2</sup>	STC	SFIBL	AFCL	RDS <sup>2,3</sup>	BLERA[1:0] <sup>2,3</sup>	ST	RSSI[7:0]										
0Bh	READCHAN	BLERB[1:0] <sup>2,3</sup>	BLERC[1:0] <sup>2,3</sup>	BLERD[1:0] <sup>2,3</sup>	READCHAN[9:0]														
0Ch	RDSA	RDSA[15:0] <sup>2</sup>																	
0Dh	RDSB	RDSB[15:0] <sup>2</sup>																	
0Eh	RDSC	RDSC[15:0] <sup>2</sup>																	
0Fh	RDSD	RDSD[15:0] <sup>2</sup>																	

### Notes:

- Any register not listed is reserved and should not be written. Writing to reserved registers may result in unpredictable behavior.
- SI4703 only.
- Available in RDS verbose mode only.



# Arduino Uno send this commands to the si4735 radio tuner

- Arduino sets the RSSI threshold (\*) for qualify the valids channels when the tuner search up the band

- Arduino sets SNR threshold(\*\*) for qualify the valids channels when the tuner search up the band

- Arduino sets the type of the RDS information to obtain:
  - PICODE - programme identification code - it's the unique 4 character hexadecimal code that identifies the station
  - PS (programme service name)- it's the station identity name.

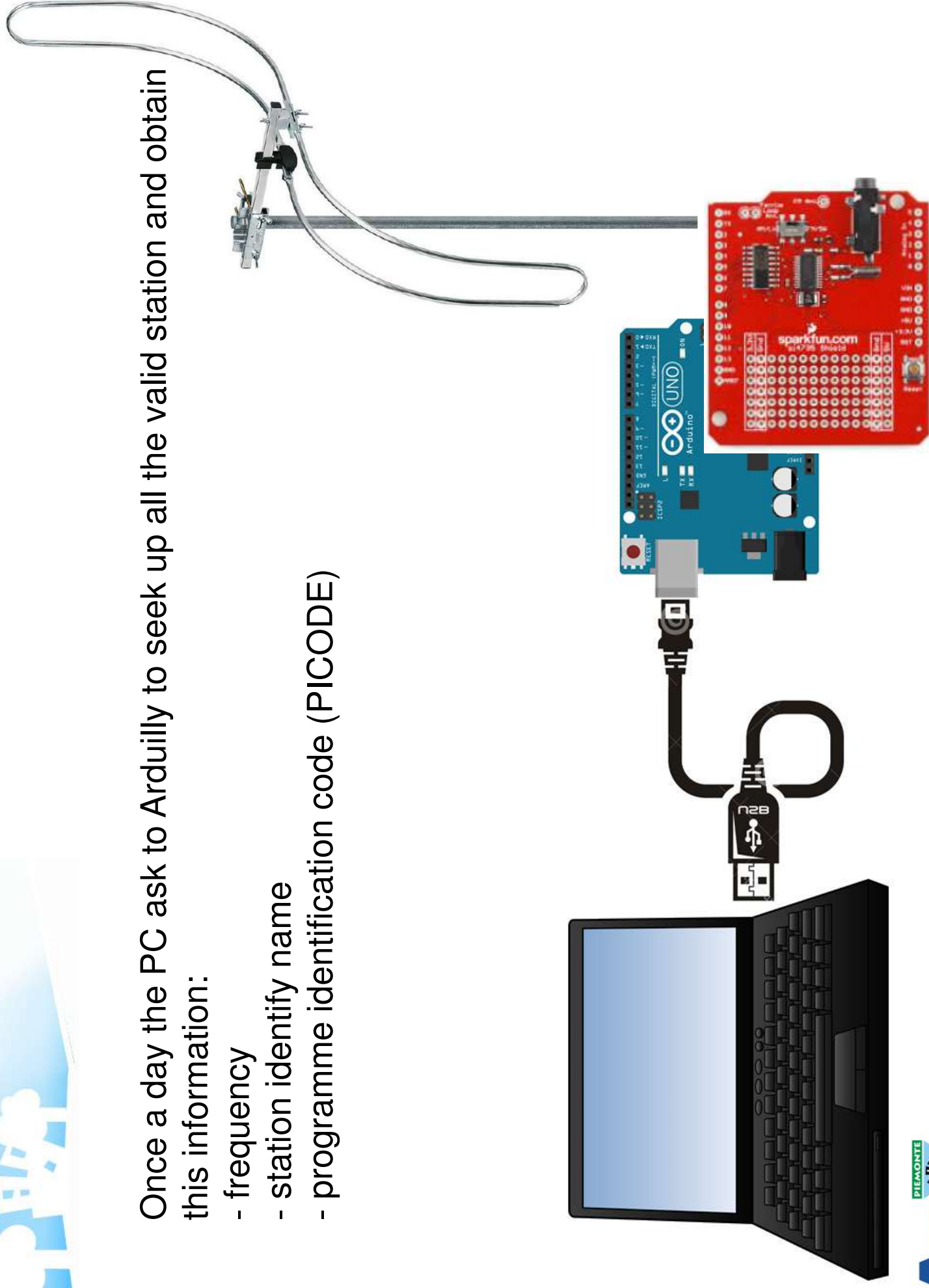
- It enables or disable the ACG circuit (automatic gain control)

- (\*) received signal strength indicator threshold
- (\*\*) the signal-to-noise ratio - threshold



Once a day the PC ask to Arduilly to seek up all the valid station and obtain this information:

- frequency
- station identify name
- programme identification code (PICODE)





## Another info: RSSI or the signal power

Since the 4735 radio tuner, for qualify the valid channels, must evaluate the level channel and compare it to the RSSI threshold, we have another info from the tuner:

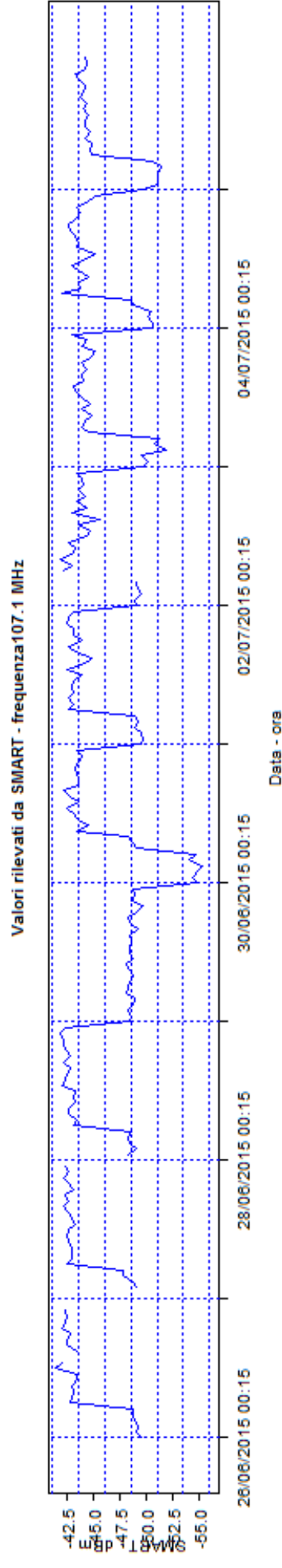
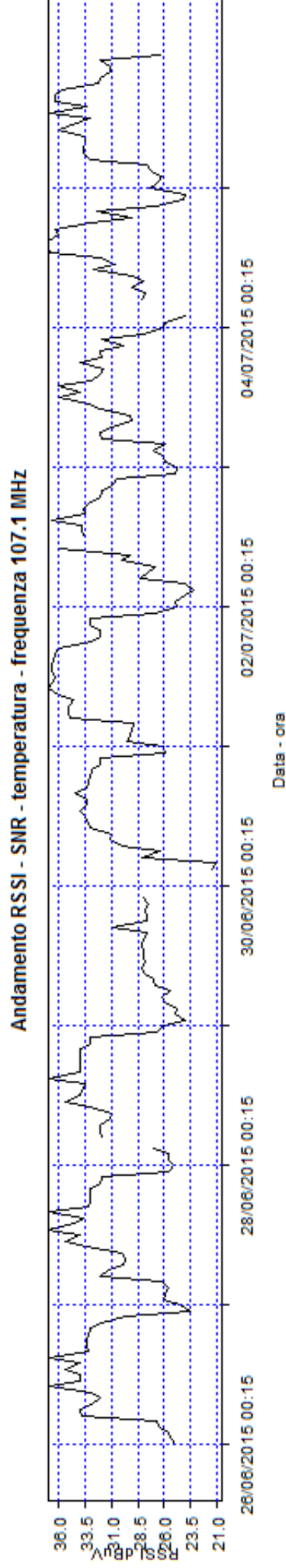
the power of the channel: the RSSI

In the Si47xx family, this power measurement is Received Signal Strength Indicator (RSSI), measured as the integrated power after the channel filter for a given channel. The RSSI seek threshold (SEEKTH) is simply the power level above which a valid channel is determined.





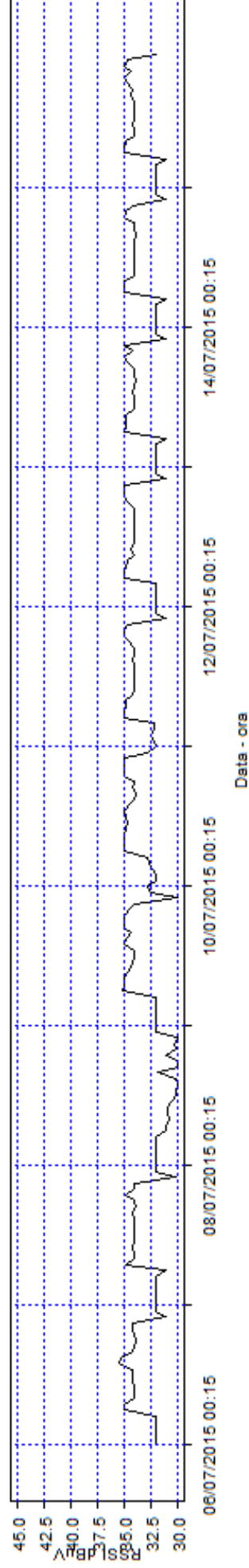
- In order to verify if the RSSI is a correct value of power we have compared it to the level read by SMART



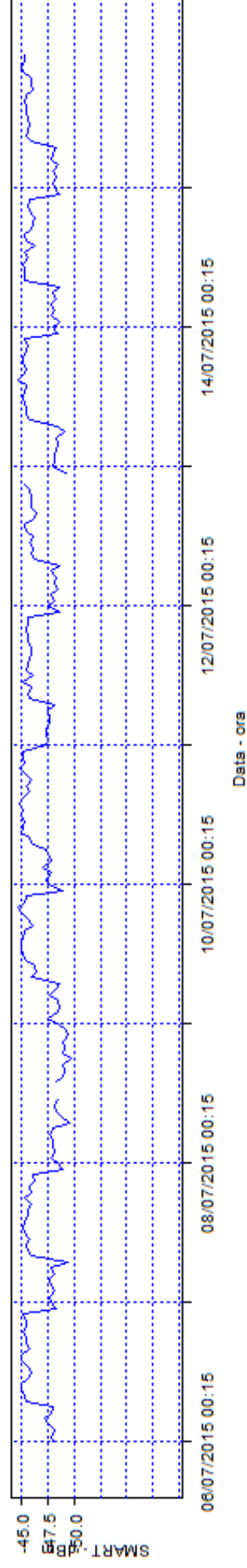


# Arduilly vs SMART

Andamento RSSI - SNR - temperatura - frequenza 98.7 MHz

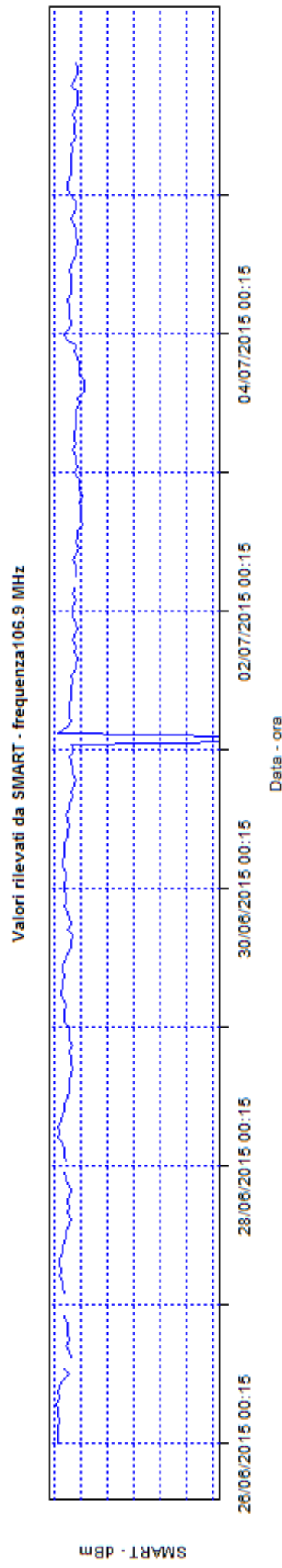
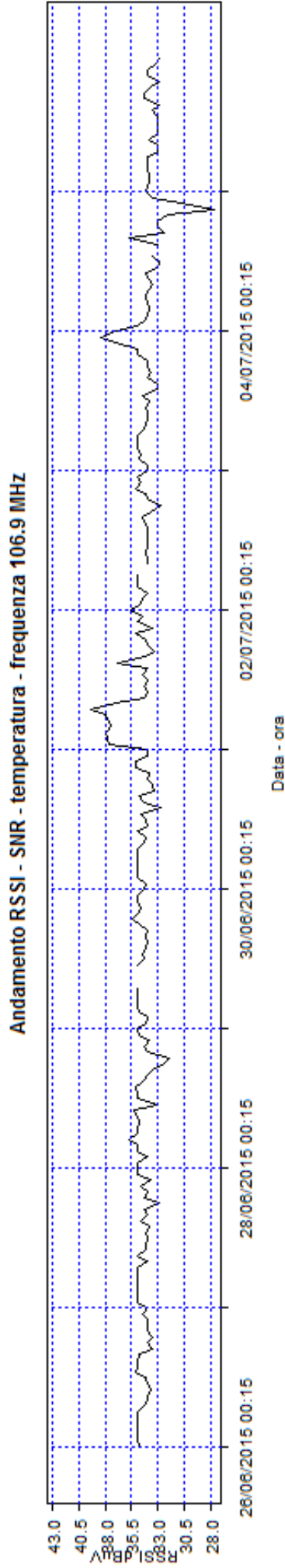


Valori rilevati da SMART - frequenza 98.7 MHz





# Arduilly vs SMART

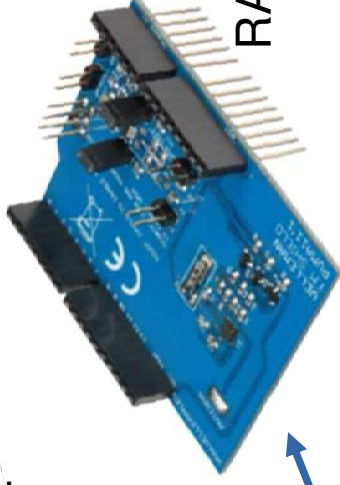




A new project with the possibility to have a portable Arduino that can save hourly the data in a memory (SD card) and, in future, to save in the cloud



REAL TIME  
CLOCK



RADIO FM



SD CARD



WIFI

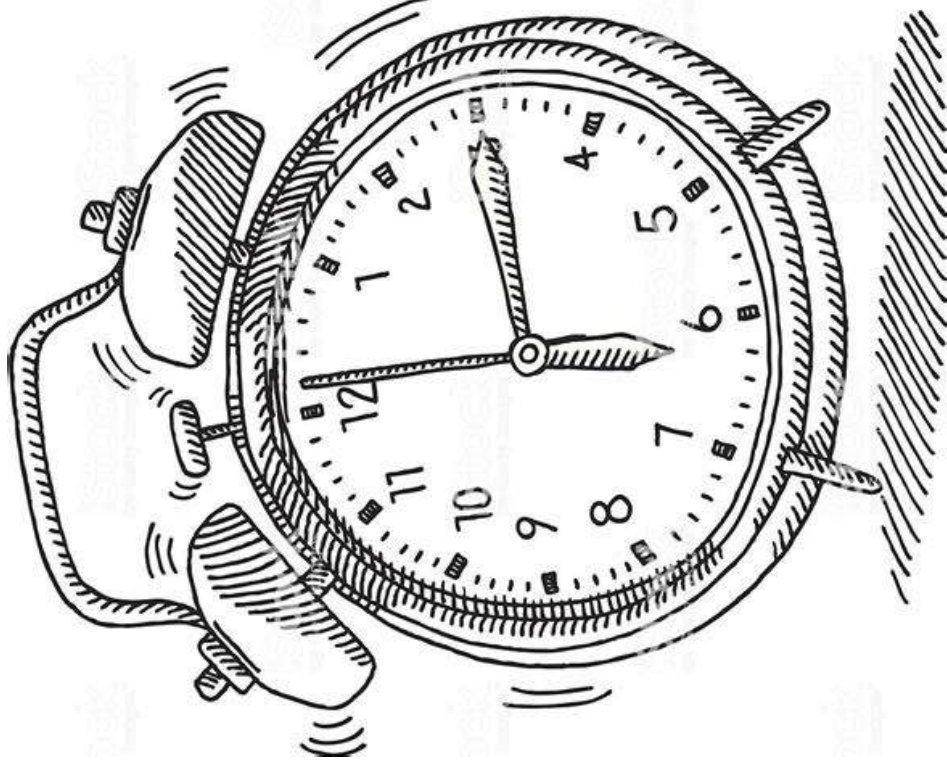
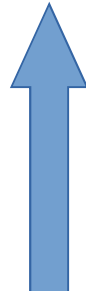


A solar panel and a battery provide to the supply power of di  
circuits





# RTC real time clock – hourly wake up the sistem

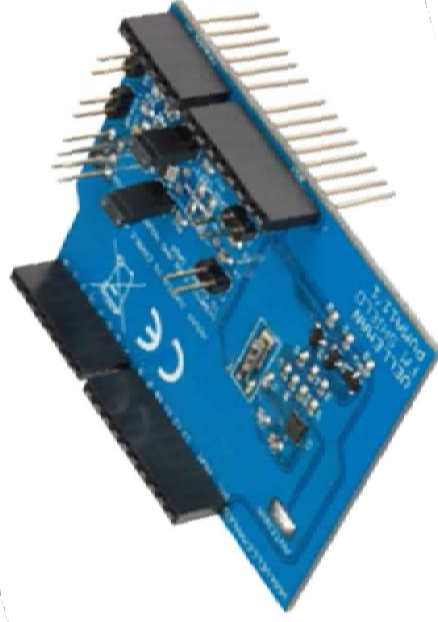


REAL TIME  
CLOCK



A new shield based on the SI4703 FM radio tuner, provide to tune the channels and gets the data

RADIO FM



SEEKS VALID CHANNEL + TUNES TO THE CHANNEL

READS CHANNEL NAME (RDS)

READS SIGNAL POWER (RSSI)



A shield that provides a storage space to read/write SD card via Arduino



SAVE ALL THE DATA

SD CARD

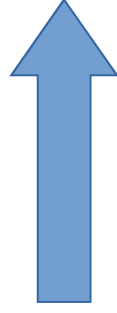




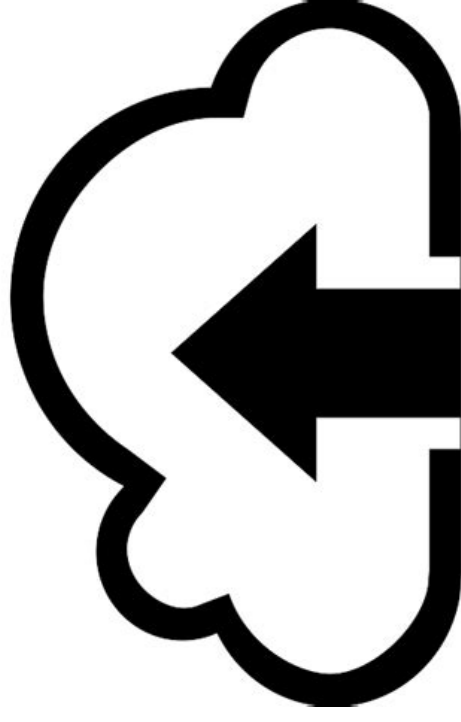
ESP8266 is a low-cost Wi-Fi microchip that allow  
arduino to connect it to the cloud



WIFI



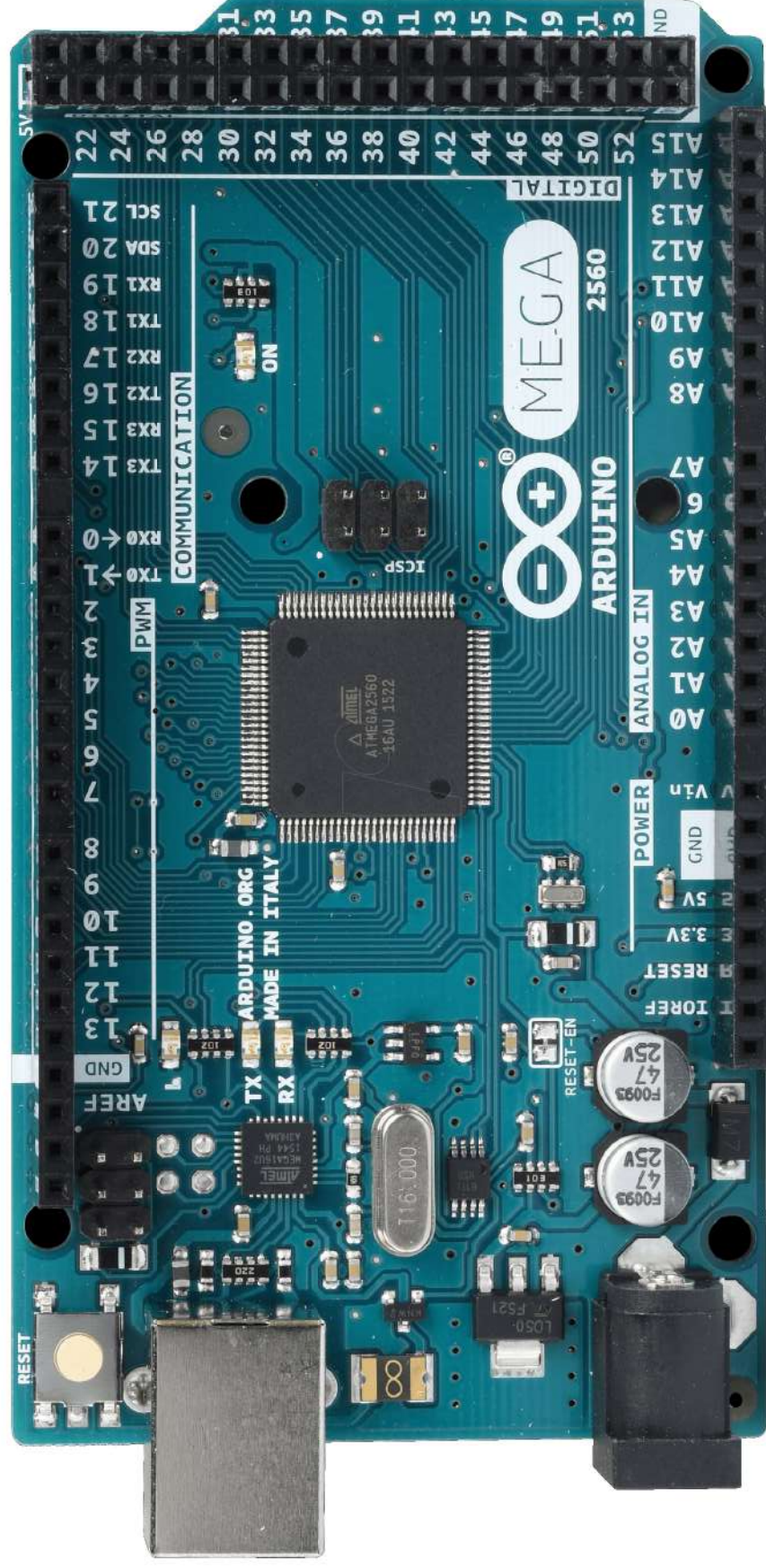
TRANSFER TO THE  
CLOUD



CLOUD



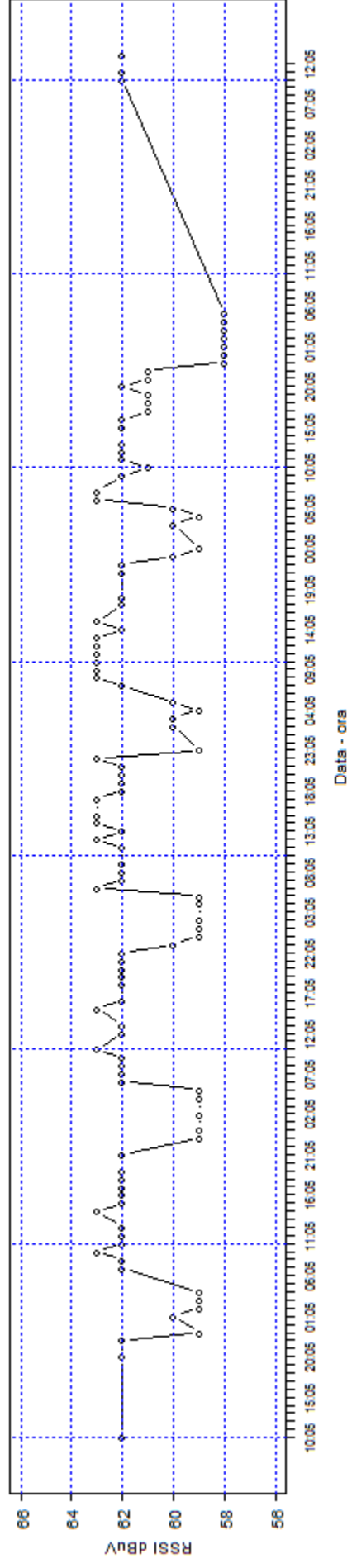
Due to the need of more memory, for this project we use a new board:  
Arduino MEGA 2560





# Graphic from 27/09/2019 h 10 to 04/10/2019 h 13

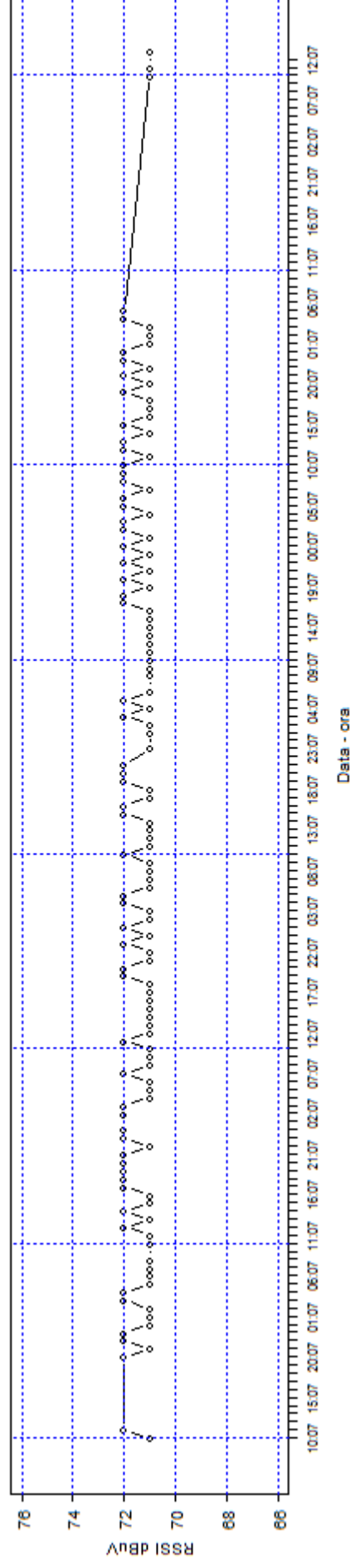
Andamento RSSI freq. 9390 MHz





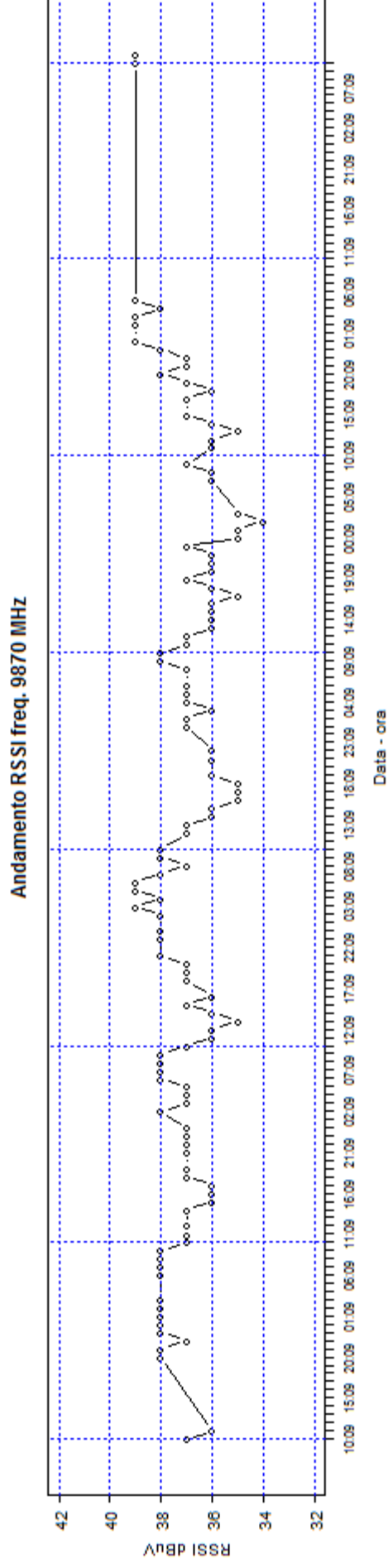
# Graphic from 27/09/2019 h 10 to 04/10/2019 h 13

Andamento RSSI freq. 9560 MHz



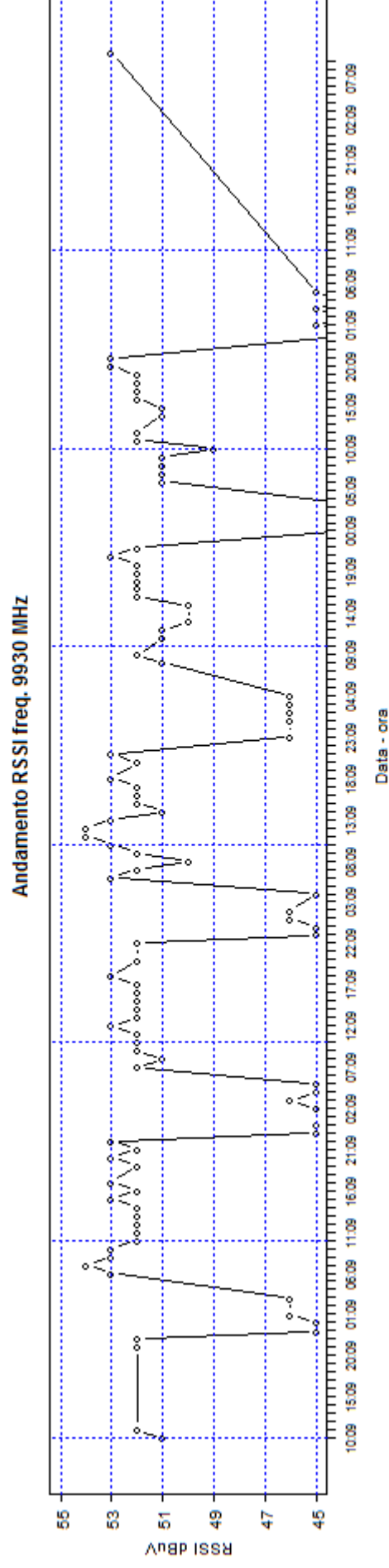


# Graphic from 27/09/2019 h 10 to 04/10/2019 h 13



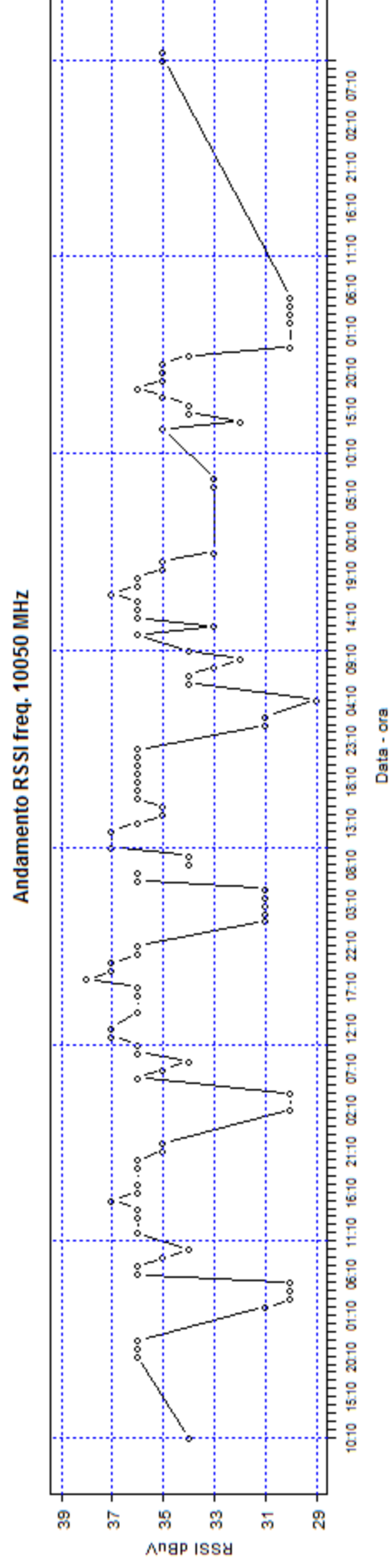


# Graphic from 27/09/2019 h 10 to 04/10/2019 h 13





# Graphic from 27/09/2019 h 10 to 04/10/2019 h 13





## Conclusions

Arduilly is able to highlight or detect typical channels variations such as switching off, switching on, changing of frequency (with the appearance of a new frequency) and periodic power downs (at night). Not being a true measuring instrument, it can in some cases show unexplained variations



## CDR – China Digital Radio

(\* )At the spring NAB Show SAPPRTF’s Director of the Academy of Broadcasting Science, Peng Gao, held a session focusing on the background of the

### CDR Project

The CDR standard, operational since November 2013, is labeled as GY/T 268.1-2013 and was published by the authority State Administration of Press, Publication, Radio, Film and Television of the People’s Republic of China (SAPPRTF).

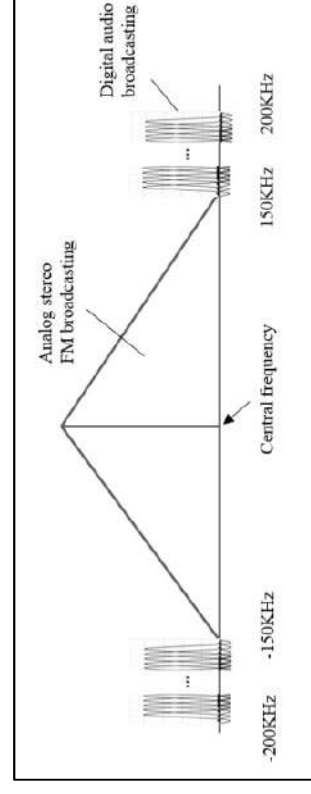
- CDR is a type of In-Band On-Channel system that works in the FM band.
- IBOC is a hybrid method for simultaneously broadcasting digital radio and analog radio in the same frequency band by placing additional digital subcarriers in the sidebands of the AM or FM channel.
- (\*) <https://www.radioworld.com/news-and-business/china-presents-its-digital-radio-standard>



Peng Gao



Parameter	FM	HD Radio	China Digital	DRM+	DAB+
<b>Frequency</b>	87.5 MHz – 108 MHz Band II	55kHz - 1705kHz 87.5 MHz – 108 MHz Band II	87.5 MHz – 108 MHz Band II	47 MHz – 68 MHz 87.5 MHz – 108 MHz 174MHz – 230 MHz	174 MHz – 240 MHz Band III
<b>Programs / Channel</b>	1	1 to 4 (max)	1 to 4 (or More)	1 to 4 (max)	Typically 9 to 24 (64 max )
<b>Data / Channel</b>	RDS 1.2 kBit/s	Flexible Program Associated and Non Program Associated Data rates	Flexible Program Associated and Non Program Associated Data rates	Flexible Program Associated and Non Program Associated Data rates	Flexible Program Associated and Non Program Associated Data rates
<b>Analog Simulcast</b>	N/A	Yes	Yes	Yes*	No
<b>Channel</b>	200 kHz	400kHz	400kHz	96 kHz	1.5 MHz
<b>BW Capacity</b>	N/A	96/124 kBit/s	96 kBit/s-1.5 MBit/s	96/k Bit/s	1.5 Mbit/s
<b>Modulation</b>	Single Carrier FM 	Multi-carrier (up to 524) OFDM, 4 QAM 	Multi-carrier (up to 524) 4,8,16,32,64 QAM 	Multi carrier (106) OFDM, 4 or 16 QAM 	Multi Carrier (1536) OFDM, type DQPSK 





Arduilly = arduino + a cup of coffee



