SPINO

Versatile open source radio system for nanosatellites

FOSDEM 2024

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2024 – 02 - 04 V 1.0

Team

Joint team between AMSAT-F & Electrolab

Core Team

- Yannick Avelino F4HDA (Electrolab / Adrelys)
- Mehdi Khairy F4IHX (Electrolab / Adrelys)
- Christophe Mercier (AMSAT-F)
- Aloïs Meckenstock (Electrolab / Adrelys)

Institutional & industrial support

https://code.electrolab.fr/spino/cubesat_cs

SPINO ?

▌ SPINO is a versatile telecommunication solution suitable for nanosatellites and Cubesats.

- Operation in UHF and VHF bands

▌ The SPINO SC board features functions dedicated to the spacecraft infrastructure :

- Receiver function for remote control commands from ground…

- Managed or Autonomous beacon (support for OBC failure)

- Data stream (uplink and downlink)

- Antenna deploy support

- And functions dedicated to the amateur radio community :
  - a versatile digital transponder
  - a digital mailbox service

▌ Maximize reliability

- wide supply voltage range,

- fail-safe on key points,

- low power consumption, especially in idle to face failure situations).

Spino Story

Ideation	Design and build	Deliver to Latmos	Alive
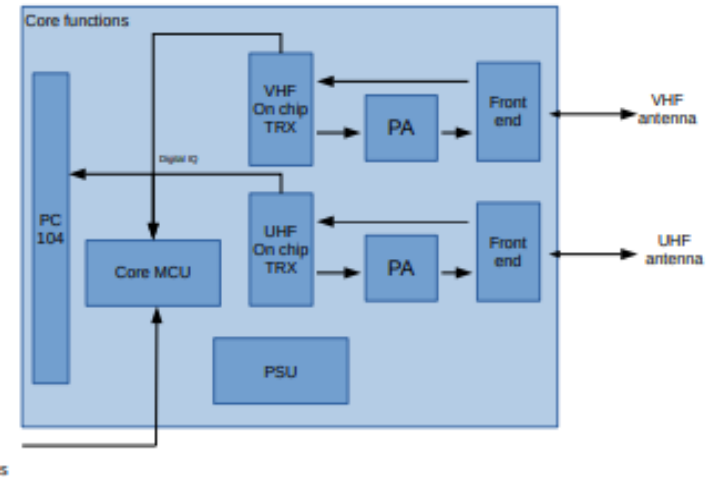
First brainstorming during 2019 « Rencontre Spatial Radioamateur »

Based on retex from cubesat (eg Xcubesat)

2021 Latmos offer to onboard SPINO in InspireSat 7

Design and build acceleration

2022/09 Spino board integrated in inspireSat 7

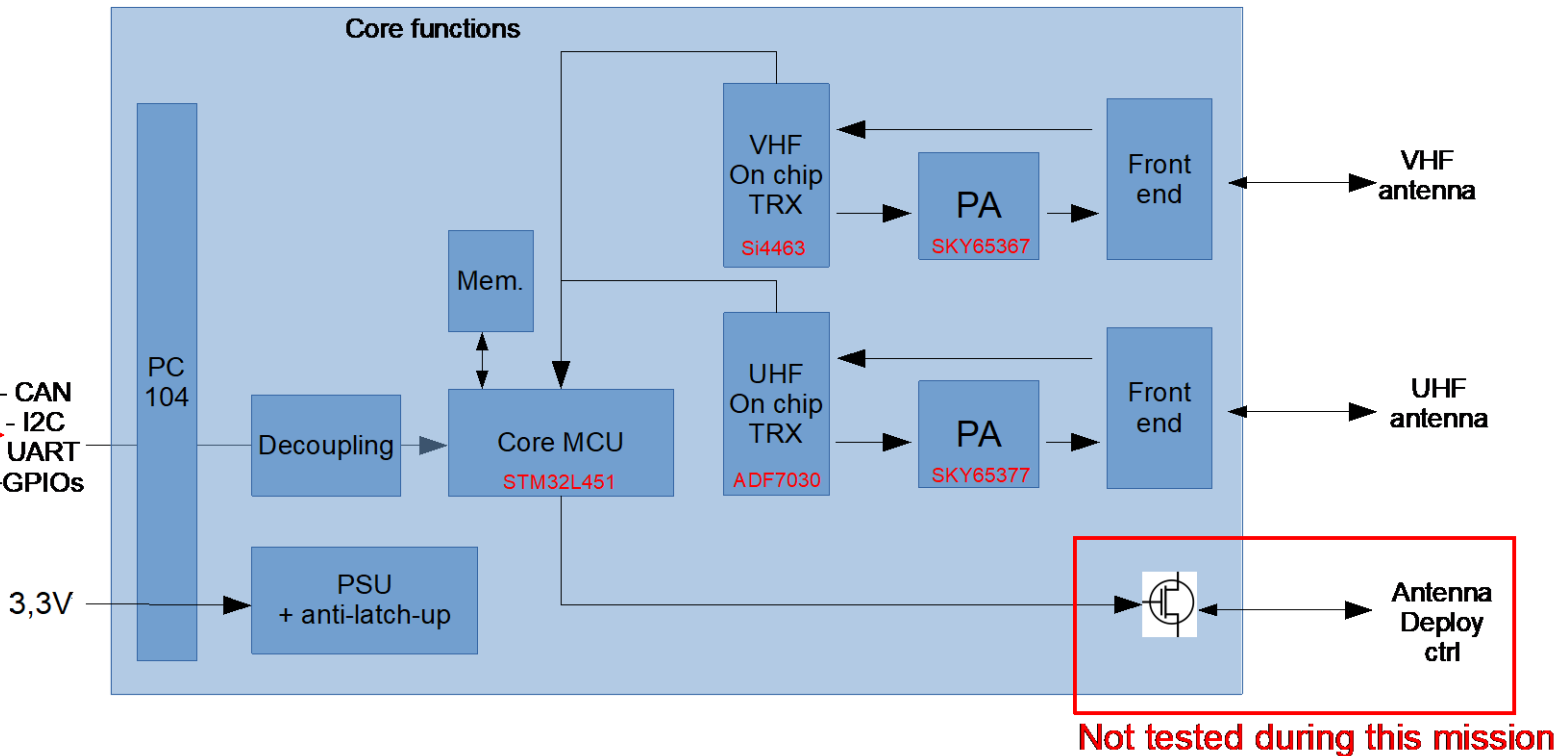Software delivered to latmos few second before the milestone

2023/04/15

InspireSat 7 launched

Spino switched on and running

Carte télécom Open pour Cubesat
Choix système

Core functions

PC 104 · Decoupling · Core MCU (STM32L451) · Mem. · PSU + anti-latch-up

VHF On chip TRX (Si4463) · PA (SKY65367) · Front end · VHF antenna

UHF On chip TRX (ADF7030) · PA (SKY65377) · Front end · UHF antenna

Antenna Deploy ctrl

I2C only For this mission → - CAN - I2C - UART +GPIOs

3,3V

Not tested during this mission

InspireSat 7 specificity

- Two separate radio systems (TRXVU and SPINO), with two frequency pairs
    - But only one ANT antenna module (VHF doublet and UHF doublet)

- SPINO uses the antenna system with a penalty in terms of antenna gain (TX in UHF, but on the VHF dipole, and RX VHF, but on the UHF dipole).
    - Penalty on dipole gain, but the "435MHz=3x145MHz" characteristic makes this penalty quite bearable (loss of 1.5dBi max)!

- Switch to MMCX connectors
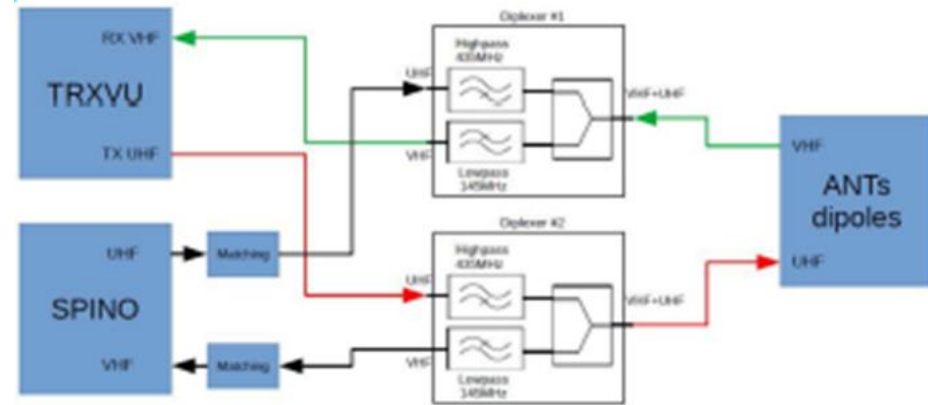
Covid 19

- Coping with supply chain disruptions Switch to BGA components for the microcontroller

## Upload frequency: *145,xxxMHz*

Download Frequency : *435,200MHz*

	Mode 1	Mode 2	Mode 3	Mode 4
	Emission / Réception	Emission Only	Emission Only	Emission Only
Modulation	**2FSK** (no deviation filter)	**2GFSK** (gaussian deviation filter, BT=0.5)	**4GFSK** (gaussian deviation filter, BT=0.5)	**4GFSK** (gaussian deviation filter, BT=0.5)
Datarate	2400bits/s	9600bits/s	10800bits/s	12800bits/s
Deviation	1200Hz	4800Hz (+/-4800Hz, meaning modulation index is 1)	4212Hz (+/-4212Hz, meaning modulation index is 0.78)	2880Hz (+/-2880Hz, meaning modulation index is 0.45)
Preamble	16x "0xAA"			
Sync Word (32bits)	0x2EFC9827			
Payload length	240 Byte			

Based on AX25 protocol with modifications

- different preamble & synchronization word at beginning
- No insertion of binary elements (ax25 flag)
- Message size added
- No "Stuffing" bit

Callsign

- SPINOD
- SPINOS
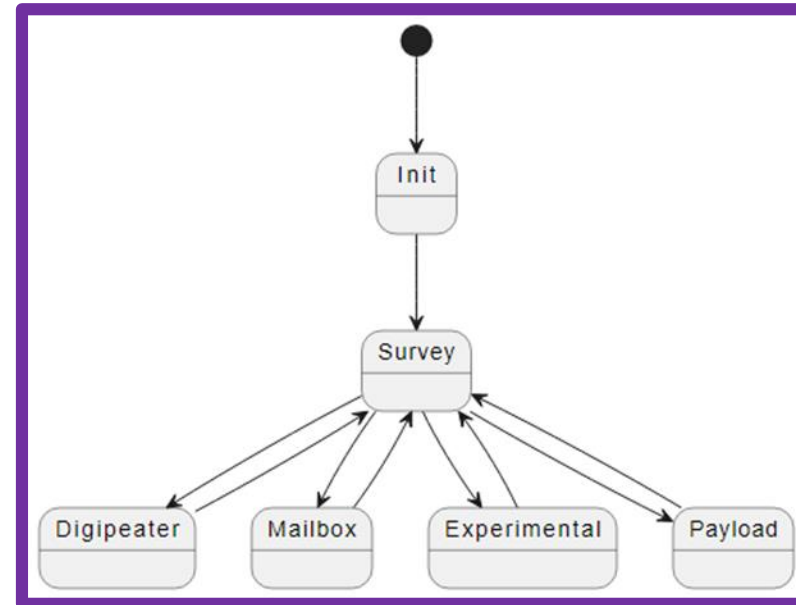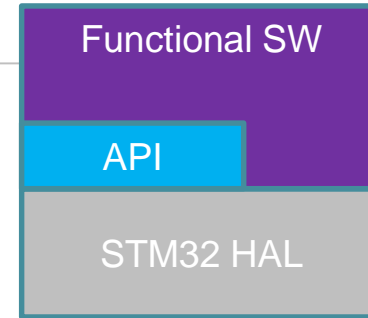
Embedded Software
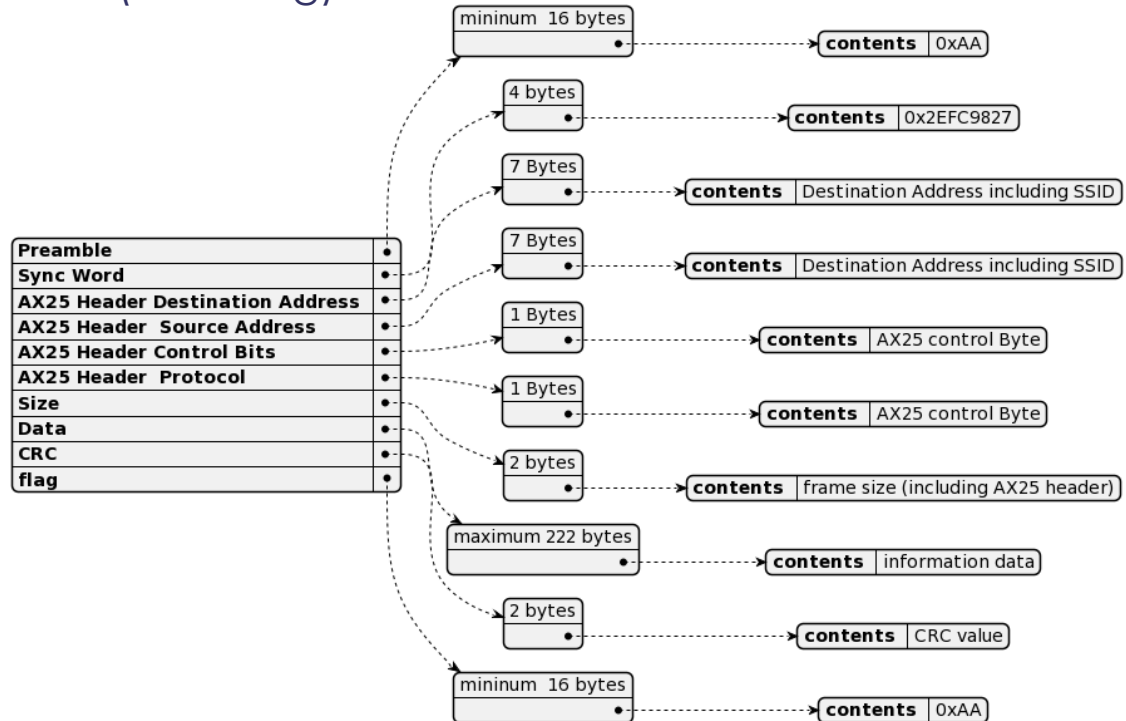
3 layers

- STM32 HAL (Hardware Abstract Layer)

- SPINO API/Driver

  - Manage TX/RX and modulation scheme

- Functional Software

Design constraints

- No dynamic memory allocation

- Simple scheduler based on state machine

- C language

Spino simulator

- Same Functional software works on simulator and embedded software

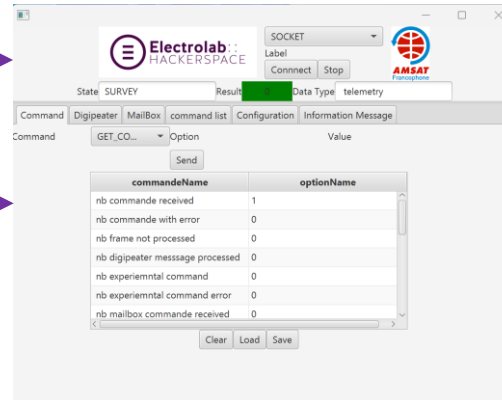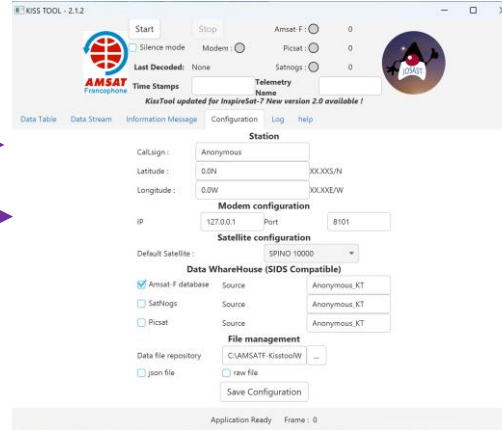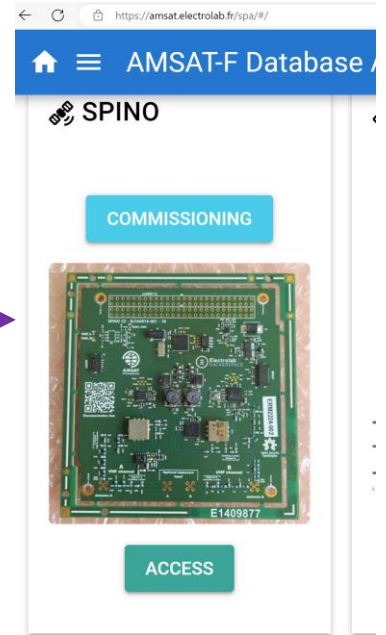- => Functional & SPINO API/Driver coded in //

SPINO Ecosystem

Spino Board

Spino Simulator

ApplicationSpinoController

Amsat-f DataBase

https://amsat.electrolab.fr

Main Objectives

- ✅ SPINO alive and send telemetry
- ✅ SPINO receive command and answer
- ✅ Test 4 communication modes
- ⚠️ Monitor board heatlh

Secondery Objectives

- ⚠️ Open Spino to general usage

Ground segment

- ✅ Spino demodulator
  - Gr-satellite
  - ⚠️ R2loud
  - SatDump
- ✅ Spino modulator control center
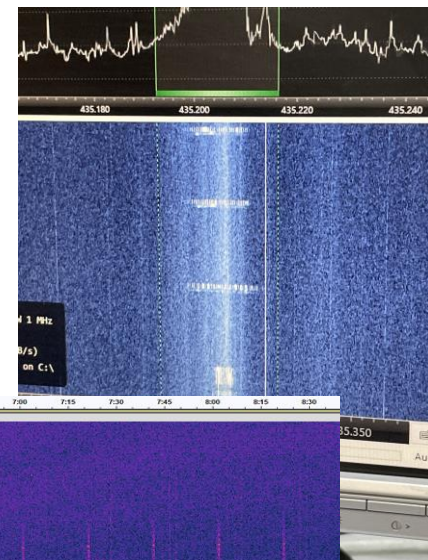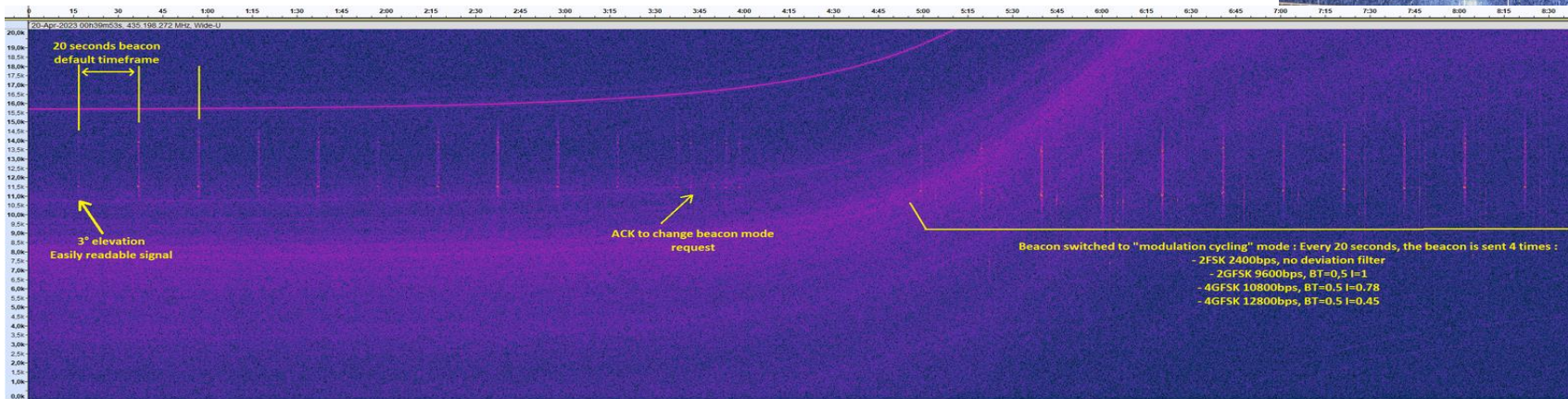- ⚠️ Spino modulator Users
- ✅ Data Decoder
  - Kisstool
- ✅ Command Control
  - SpinoApplication Controler

In-flight commissioning

First activation for 24h on 19/04/2023

- Heard from the very first orbit !

SPINO is alive !

- First attempt to send an instruction on the night of April 19-20

20-Apr-2023 00h39m53s, 435.198.272 MHz, Wide-U

20 seconds beacon default timeframe

3° elevation Easily readable signal

ACK to change beacon mode request

Beacon switched to "modulation cycling" mode : Every 20 seconds, the beacon is sent 4 times :
- 2FSK 2400bps, no deviation filter
- 2GFSK 9600bps, BT=0,5 I=1
- 4GFSK 10800bps, BT=0.5 I=0.78
- 4GFSK 12800bps, BT=0.5 I=0.45

SPINO Next Steps

InspireSat 7 SPINO

- Publish modulator & Command Control application

- Open to general use

SPINO Board V2

- Update design based on retex

- Launch new batch (up to 10 boards)
    - Cubesat projects interested to on-board SPINO

Educational usage

- At least 2 university used Spino in internship periods

Contact

- https://amsat-f.org

- https://www.electrolab.fr

Open source

- Spino :
    - https://code.electrolab.fr/spino/cubesat_cs
- Josast :
    - https://code.electrolab.fr/xtof/josast