SPINO

Versatile open source radio system for nanosatellites

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Team

Joint team between AMSAT-F & Electrolab

Core Team

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

Institutional & industrial support

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

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
SPINO Hardware

Core functions

I2C only
For this mission

VHF
On chip TRX
Si4463

PA
SKY65367

PC 104
- CAN
- I2C
- UART
+GPIOs

Decoupling

Core MCU
STM32L451

Mem.

PSU
+ anti-latch-up

3.3V

UHF
On chip TRX
ADF7030

PA
SKY65377

Front end

Not tested during this mission

VHF antenna

UHF antenna

Antenna Deploy ctrl
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
**SPINO Frequency and mode**

- **Upload frequency:** 145,xxxMHz
- **Download Frequency:** 435,200MHz

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

Kisstool

Spino Simulator

Application SpinoController

Amsat-f DataBase

https://amsat.electrolab.fr
InspireSat 7 – Spino Status

Main Objectives

- SPINO alive and send telemetry
- SPINO receive command and answer
- Test 4 communication modes
- Monitor board health

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 Controller
In-flight commissioning

First activation for 24h on 19/04/2023

• Heard from the very first orbit!

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

Open source

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