Custom Amateur Radio Sensors for the AmbaSat Platform

Michelle Thompson W5NYV

Chief Executive Officer

Open Research Institute

Contributing Authors

Howie DeFelice AB2S
Douglas Quagliana KA2UPW/5
Jim Tittsler 7J1AJH / ZL2IA
John Ackermann N8UR
Zach Leffke KJ4QLP
Ron Economos W6RZ
Kent Britain WA5VJB

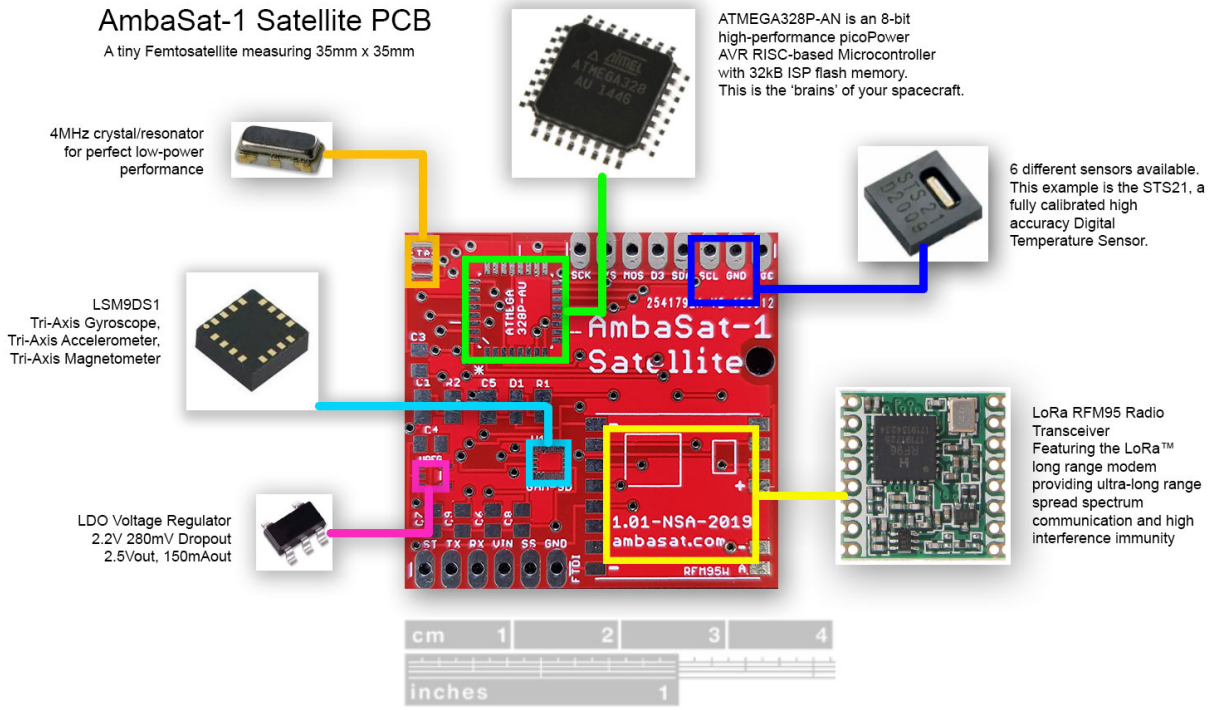
June 19, 2020

Abstract

The AmbaSat project was a crowdsourced Low Earth Orbit (LEO) satellite program.

From https://www.indiegogo.com/projects/ambasat-1-a-lorawan-space-satellite-kit#/

“AmbaSat-1 is a tiny Space satellite kit that you assemble and code yourself. Once your satellite kit is assembled and programmed, it will be launched on-board a commercial rocket into Low Earth Orbit, where it will spend up to 3 months in space. AmbaSat-1 uses LoRaWAN and The Things Network to send live data back to Earth. No special radio equipment is needed, you can view your satellite's data via the internet.”



AmbaSat-1 is tiny space satellite kit that you assemble and code yourself. Once your satellite kit is assembled and programmed, it will be launched onboard a commercial rocket which will deploy your satellite into Low Earth Orbit, where it will spend up to 3 months in space.

Several sensors were included. See above diagram from AmbaSat for details.

There is also a space on the board for an additional sensor. There were 8 choices of sensor given to backers. Details of those 8 sensors are in the References section. Datasheets for the sensors are available from the Indiegogo page linked above.

AmbaSat-1 also offered a custom sensor option.

“You can create a custom sensor as long as it conforms to certain criteria, including size and safety. Your AmbaSat satellite provides additional connectivity pins which expose the ATMEGA’s I2C bus, as well as digital and analogue pins, plus power. Please contact custom@ambasat.com for more details.”

This document captures discussion about building custom sensors based on AmbaSat hardware and software.

Because AmbaSat is open source, sensors compatible with amateur radio interests can be designed, built, tested, and launched using AmbaSat as a delivery platform. This re-uses and extends the successful design work done by an open source team.

Introduction

The AmbaSat satellite software is fully open-source and available for full download. The AmbaSat satellite hardware is also totally open source and the schematics and Bill of Materials (BoM) are available for download.

Here is the repository for AmbaSat-1.
https://github.com/ambasat/AmbaSat-1

Here is the guidance from AmbaSat for their custom board options. This was received on 4 November 2019.

The maximum mechanical envelope for the custom board is 35 mm wide x 35 mm length x 7 mm in height. The height may change but it will be no less. It may change if there are alterations required to the deployment mechanism to meet UK Space Agency requirements.

Position and diameter of the release hole: This is currently 13 mm from the top of the board and 2mm to the centre of the hole from the right edge. The diameter is 3 mm.

There should be 0.7mm 'keepout' zone around the edge of the board. This is except for the daughterboard connectors and FTDI connectors (Yours may not feature these of course)

Please see the latest AmbaSat Github Eagle files for further information, including the custom sensors. Here:
https://github.com/ambasat/AmbaSat-1/tree/master/Release/Eagle/Motherboard

Additionally, the custom sensor should support the I2C format with a voltage of 2.1v. For reference, please see the ambaSat-1 range of sensors here:
https://ambasat.com/ambasat-2/sensor-options/

Board thickness - we use 1mm for the mainboard and 1mm for daughterboard and 1mm for the solar board.

Best regards,

Martin.

Purpose

The purpose of this document is to propose building amateur radio equipment inspired by the custom sensor option from AmbaSat.

Dr. Alan Johnston and Dr. Jonathan Black are both interested in collaborating on this project with their aerospace students.

Open Research Institute has a high degree of confidence that additional university collaborations will arise with funding.

Importance of the Project

It's important to take advantage of opportunities to put useful capabilities in space. Having hardware and software ready to go has become increasingly important as launch opportunities become more diverse and shorter in timeframe.

We believe LoRA on a LEO would make a great Store and Forward messaging satellite. The chirp spread spectrum modulation handles doppler quite well. LoRA chips on carrier boards make for inexpensive ground stations. The basic premise of AmbaSat is a good one.

AmbaSat is a controversial project for several reasons. The size of the satellite is very small. There is concern that taking the design and attempting to launch it from the United States would result in an FCC license being denied. The launch provider selected has no successful launches. The Kickstarter campaign did not make enough money to purchase a launch from a larger provider.

However, space is not the only potential target. Circuits this small can be used for educating students about satellites, can be launched as lightweight balloon payloads, can be fired on model rockets, and can be incorporated into wearables, vehicles, and drones.

This proposal sets aside the issues with the original launch schedule to look at the systems, hardware, and software designs. Controversy over the launch is not relevant to the collection of sensor designs that can help amateur radio in both terrestrial and space deployments.

Method of Approach

Design, document, build, and test.

Design consists of capturing the sensing and/or actuation as a text description.

Documentation is whatever is required to reproduce the particular “sensor” design.

Build is a working prototype that complies with the AmbaSat specifications.

Testing is hardware and software performing without failure in the environment specified.

Proposed Designs

Beacons

Unmodulated Carrier with Doppler

A stable oscillator for some frequency in an amateur satellite band. We would need the oscillator, a small amplifier, and an antenna. There's good science we can do from an unmodulated carrier with Doppler, even if it is an inefficient antenna and a few milliwatts of radiated power.

Two Phase-Locked Beacons

Design two phase locked beacons on 144 and 430 so that differences in Doppler might be detected. This was an ionospheric/environmental experiment implemented in (the yet to fly) KiwiSAT.

http://kiwisat.org.nz/beacon.html

Carrier and Beacon at 10 GHz

Carrier at 10 GHz. Integrate CW ID to make a beacon. 2kHz/second doppler is expected at 10.4 GHz at LEO.

Summary

Any beacon on any band, Doppler is fun.

Budget

Line Item	Amount
AmbaSat Satellite Platform Quantity 10	$1200
Unmodulated Carrier with Doppler “Sensor” development	$1000
Two Phase-Locked Beacons “Sensor” development	$1000
Carrier and Beacon at 10 GHz “Sensor” development	$1000
Total	$4200

Development costs include component engineering, bill of materials, shipping, and prototype builds. This project takes advantage of circuit printing services that have been donated to Open Research Institute that reduce printed circuit board costs and turnaround time.

References

Sensor Choices given to Backers

There are eight sensors choices available, shown in the table below. Only a single sensor can fit on the AmbaSat-1 board. Four of the sensors require a small additional payment. The other sensors are included in the original backer options.

SHT30-DIS-F2.5KS

Humidity and Temperature – Best in class Humidity & Temperature Sensor. Fully calibrated, linearized, and temperature compensated digital output with a wide supply voltage range, I2C Interface with communication speeds up to 1MHz and two user selectable addresses.

Typical accuracy of 1.5 %RH and 0.1 °C. Very fast start-up and measurement time. All in a tiny 8-Pin DFN package.

STS21

Temperature – A 3x3mm, fully calibrated digital temperature sensor with impressive performance.

The temperature sensor features a I²C address and comes with outstanding accuracy and low power consumption.

BME680

Gas, Pressure, Temp & Humidity – a low power gas, pressure, temperature & humidity sensor. It is a 4-in-1 multi-functional MEMS environmental sensor which integrates VOC (Volatile Organic Compounds) sensor, temperature sensor, humidity sensor and barometer.

Monitor 4 environmental parameters simultaneously. Widely used in environmental monitoring, home automation and control, Internet of Things (IoT) wearable device, GPS, etc.

OPT3001DNPT

Ambient Light Sensor – The OPT3001 is a sensor that measures the intensity of visible light. The spectral response of the sensor closely matches the photopic response of the human eye, with infrared rejection. It is a single-chip lux meter, measuring the intensity of light as visible by the human eye.

The precision spectral response and strong IR rejection of the device enables the OPT3001 to accurately meter the intensity of light as seen by the human eye regardless of light source.

ZMOD4410AI1V

TVOC (Total Volatile Organic Compounds) – Designed for detecting total volatile organic compounds (TVOC). The ZMOD4410 is a 12-pin LGA assembly (3.0 x 3.0 x 0.7 mm) that consists of a gas sense element and a CMOS signal conditioning IC.

The module's sense element consists of heater element on a Si-based MEMS structure and a metal oxide (MOx) chemiresistor. The signal conditioner controls the sensor temperature and measures the MOx conductivity, which is a function of the gas concentration.

SI1132-A10-GMR

UV Sensor – The Si1132 is a low-power, ultraviolet (UV) index, and ambient light sensor with I2C digital interface and programmable-event interrupt output. This sensor IC includes an analog-to-digital converter, integrated high sensitivity visible and infrared photodiodes, and digital signal processor.

The Si1132 offers excellent performance under a wide dynamic range and a variety of light sources including direct sunlight.

CCS811B-JOPD500

TVOC & CO2 – The CCS811 is an ultra-low power digital gas sensor solution which integrates a metal oxide (MOX) gas sensor to detect a wide range of Volatile Organic

Compounds (VOCs) and includes an Analog-to-Digital converter (ADC), and an I²C interface.

Supporting intelligent algorithms to process raw sensor measurements and output equivalent total VOC (eTVOC) and equivalent CO2 (eCO2) values.

TESEO-LIV3R*

GPS – The Teseo-LIV3R module is an easy to use Global Navigation Satellite System (GNSS) standalone positioning receiver IC working simultaneously on multiple constellations.

This certified module comes with optimized RF, embedded firmware and is compact at only 9.7×10.1 mm.

Supporting GPS, Glonass, BeiDou & QZSS positioning systems.