Custom Sensors for AmbaSat

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October 28, 2019

Abstract

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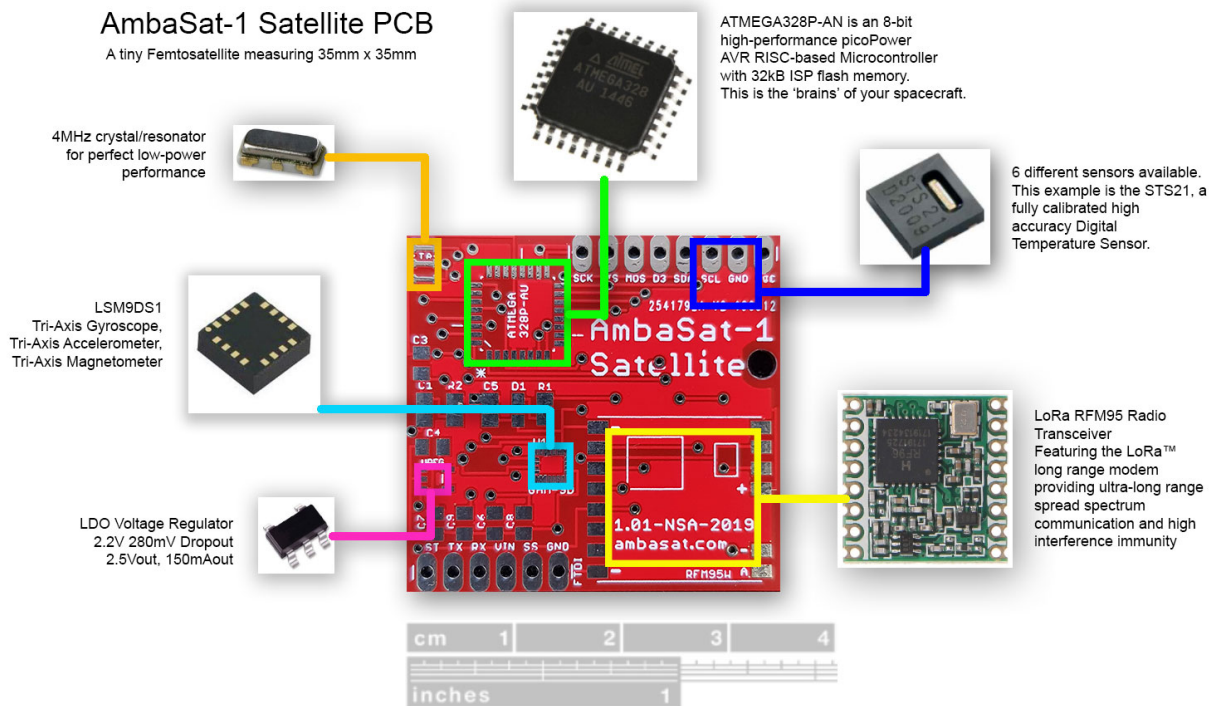
AmbaSat-1 is tiny space satellite kit that you assemble and code yourself. Once your satellite kit is assembled and programmed, it will be launched onboard a commercial rocket which will deploy your satellite into Low Earth Orbit, where it will spend up to 3 months in space.

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 custom sensors for 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.

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 sensor option.

Purpose

The purpose of this document is to gather and share ideas inspired by the custom sensor option from AmbaSat.

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.

This paper sets aside all of those issues 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 space.

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 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

1. 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
Total	

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.