National Center for Atmospheric Research
Earth Observing Laboratory
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Status Report
Project Title: Development of Miniaturized In-situ Sounding Technology for THORPEX
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General

The development of the MIST sonde for Driftsonde continues on the engineering design of the MIST sonde. The engineering effort in the past six months has been focused in five areas:

1. 400 MHz transmitter design
2. GPS receiver testing and data evaluation using the standard Dropsonde (for Winds measurement)
3. Microprocessor firmware development
4. Preliminary sensor development
5. MIST Sonde command and control from the Gondola system computer

400 MHz transmitter

The 400 MHz transmitter will be based upon the ChipCon CC1070 IC. Extensive testing was performed on this IC as the main building block for the 400 MHz transmitter. RF measurements were made of spectral purity, modulation linearity, RF bandwidth, frequency tuning range and RF output power. Also evaluated were programming requirements, and power efficiency. This Integrated RF IC has almost all functions required of a transmitter all within the IC requiring very few external components. The RF output power is 10 mw which is below the required 100mW level required for Driftsonde, so an additional RF power amplifier will need to be designed to increase the RF radiated power level, which will be based upon a singe transistor design or MMIC amplifier. Figure 1 is a photo of the CC1070 RF IC that was evaluated.

Figure 1 RF ASIC 400 MHz transmitter evaluation board

Below are three of over 40 plots characterizing the RF performance of the CC1070 transmitter IC that was made in the past 6 months. The full detailed engineering report is available on request of the transmitter IC.

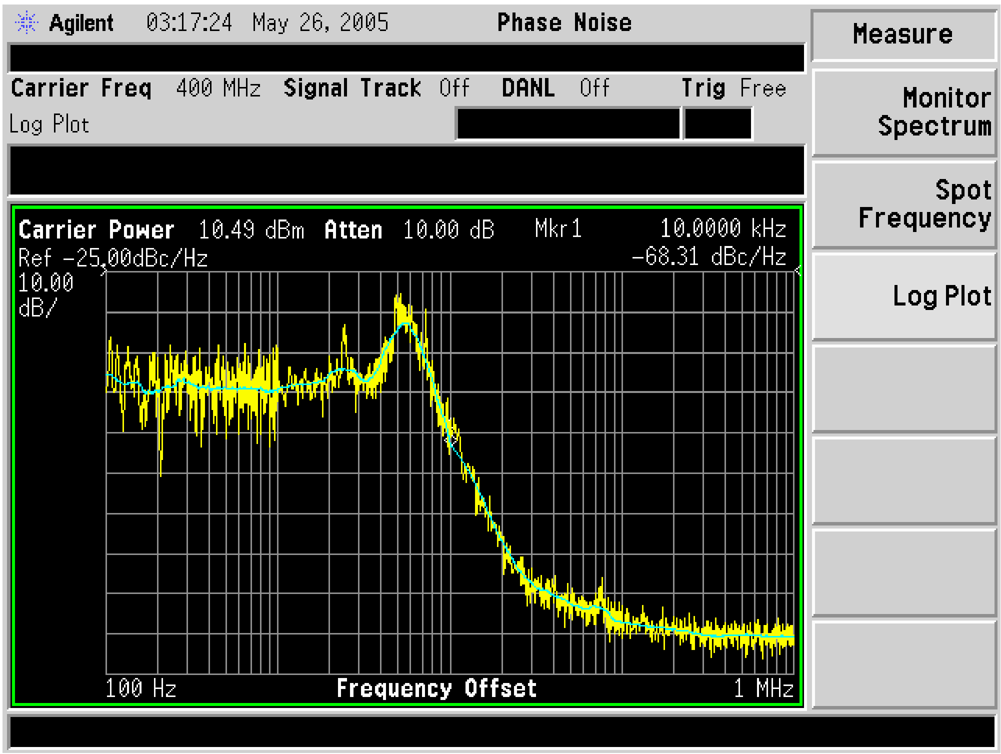

Fig. 2 – 400 MHz, 2400 Baud, FSK Modulation

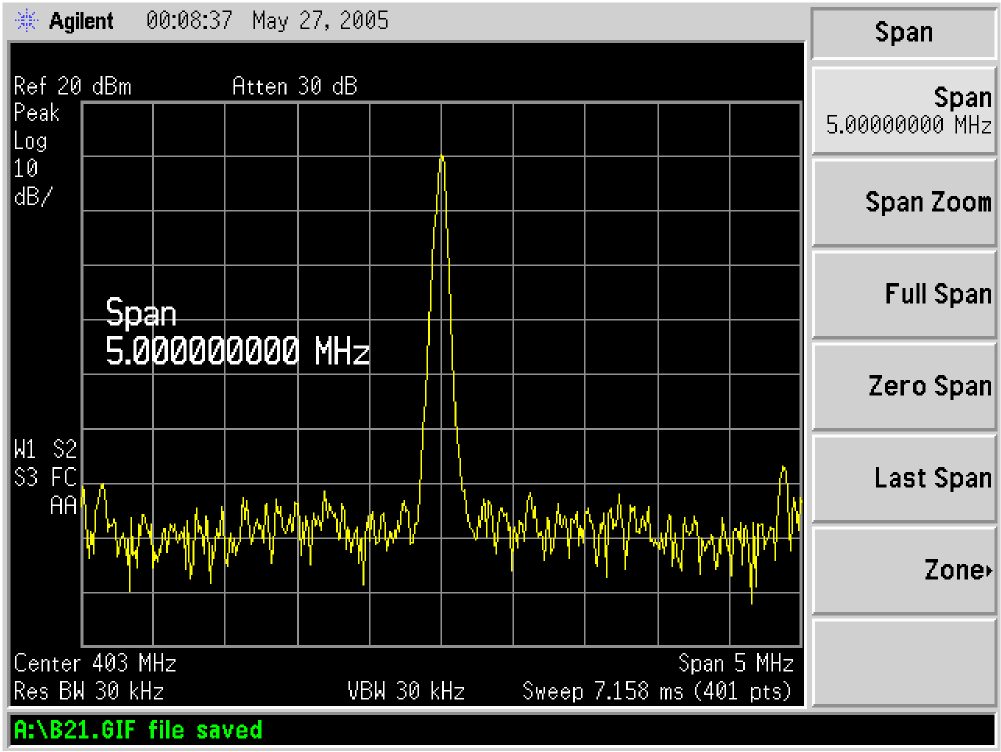

Fig. 3 – 403 MHz, 5 MHz Span, No Modulation

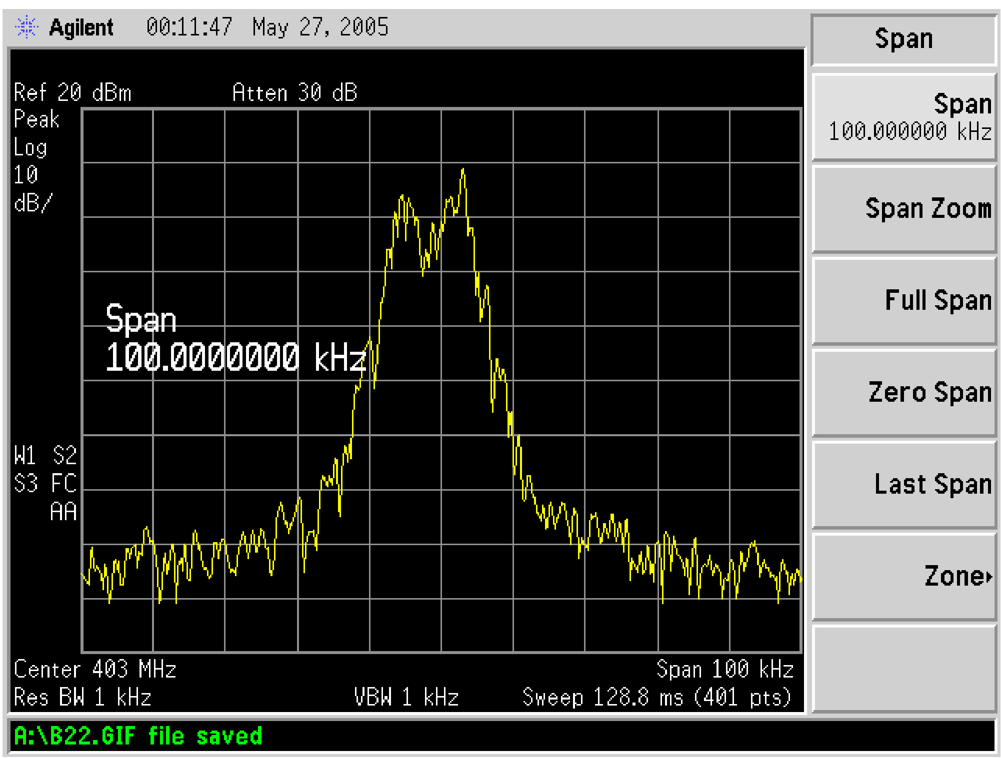

Fig. 4 – 403 MHz, 100 kHz Span, 2400 Baud GFSK Modulation

GPS Receiver

The GPS receiver and antenna are key components in the MIST sonde for determining height and winds. There has been continued testing of the u-Blox GPS receiver in standard dropsondes from NOAA/AOC aircraft. The GPS performance of the receiver from these drops has been evaluated for satellite lock-up times, satellite carrier-to-noise tracking performance and number of satellites tracked. The support circuitry for the GPS receiver has been refined to improve manufacturing issues, thus improving the overall reliability. The performance of the GPS receiver has been tested over the temperature range from -60° C to +80° C in an environmental chamber evaluating the carrier noise ratio for satellite tracking performance. These environmental tests are critical to ensure proper operation of the MIST Sonde in the gondola where at 75 mb there are significant temperature extremes. In testing of the u-Blox GPS receiver in a standard dropsonde there have been new technical issues discovered with satellite acquisition time. During the past several months there has been a large portion of time spent evaluating and testing the u-Blox GPS receiver to try to identify the cause for the long lock up times. A new version of the u-Blox GPS receiver (TIM-LH) GPS receiver is currently under investigation which may have improved performance for the driftsonde application. . Three GPS antennas have also been evaluated for immunity from RF interference and overload protection. The three antennas evaluated were the Trimble model 45336-00 antenna, Wi-Sys model WS3964 and Wi-Sys WS3967 antennas. All three are small ceramic patch antennas with a built in preamp. The difference in performance of each antenna was determined by the preamp's noise figure, gain, filter shape characteristics and overload capability. The Trimble and WS3967 were the best performing antennas, showing the best filtering characteristics and overload protection. The final descision will be based upon cost and weight.

Firmware development

Microprocessor circuit design and firmware development has continued for the MIST sonde. The type of microprocessor to be used will be a MicroChip 18F component, also evaluated was the MicroChip 16F family. Several tests were performed on MicroChip 16F parts, but to meet the design goals the firmware would need to be written in assembly, which adds a significant amount of engineering time to the firmware development task. While the 18F part is twice the cost of the 16F parts the 18F has substantially more memory which is critical for a robust system that could be developed in a high level language such as C. Firmware code has been developed in C to ingest data from the u-Blox GPS module and phase lock the internal timing of the microprocessor to the output message of the GPS receiver. The phase locking of the microprocessor to GPS receiver ensures that the thermodynamic data measurements coincides with the GPS winds measurement proving an accurate measurement of winds and temperature at the same altitidue level. The firmware code developed also has implemented the generation of a 2400 baud manchester encoded data stream for the 400 MHz transmitter. A prototype circuit was built to test and evaluate the performance of the firmware code. The data steam was successfully demodulated by another microprocessor providing a serial RS-232 data stream to a PC for data collection. This potion of the firmware is working very well, meeting the MIST Sonde requirments.

Sensor investigation
A detailed evaluation of small bead thermistors was done during our STRATO 2C design study for the German Aerospace Research Establishment's (DLR) high-altitude research aircraft that was scheduled to fly at altitudes between 16 and 26 km dropping GPS dropsondes. Several temperature manufacturers were evaluated for their ability to produce small bead thermistors during the design study and re-evaluated more recently (e.g. YSI/VECO, Honeywell/Fenwall & Thermometrics). When taking into consideration all the errors (e.g. sensor accuracy, sensor time constant and solar & IR radiation) associated with making an ambient temperature measurement from a falling dropsonde the following specifications were determined:

MIST Temperature Specifications

Measurement	Range	Accuracy	Resolution
Temperature	-70 to +50 C	+/- 0.25 C	0.1 C

The accuracy of the sensor is a function of the accuracy of its calibration curve. Most thermistors are supplied with a calibration curve that is calibrated at one point for that size sensor and is accurate to within a given percent (e.g. 5%, 10%, 20%) of it's resistance at 25˚C. In order to meet our accuracy requirements of +/- 0.25˚C over the entire temperature range it will require the sensors to be calibrated at three points and then the temperature resistance calibration curve fit to those points using the Steinhart-Hart equation. Because the resistance range of a 10 K Ohm thermistor over the temperature range of -90 to +50˚C is 964 K Ohms @-90˚C to 3.6 K Ohms @ +50˚C a minimum of a 12 bit A/D converter is required. Figure 5 shows the temperature measurement sensitivity and output voltage of a thermister resitive network. A 12-bit A/D will meet the needs for resolution, but if the number of bits for the A/D is increased to 16 the sensitivity will be excellent over the complete temperature range. A 16 bit A/D will provide a temperature resolution in excess of 0.05°, but the electrical noise and computational errors will set the practical resolution to a higher value.
To reduce the sensor time constant and the effect of radiation on the sensor the thermistor bead should be as small as possible but not so small that it is easily damaged. YSI/VECO makes a 43 mil-inch diameter glass encapsulated bead thermistor that has approximately the following time and dissipation constants at different altitudes and fall velocities:

43-mil-Thermistor Time & Dissipation Constants

	Still Air @1000 mb	10 m/s @1000 mb	25 m/s @100 mb	50 m/s @30 mb
Time Constant	6.0 s	1.5 s	2.5 s	3.4 s
Dissipation Constant	0.35 mW/˚C	1.4 mW/˚C	0.78 mW/˚C	0.67 mW/˚C

The time constants were determined by a theoretical model as well as in a special altitude chamber that was developed at DLR that can simulate pressure altitude as well as fall velocity. The dissipation constant is a measure of the thermistor's ability to dissipate any internally generated heat (i.e. I^2R heating from too high a measuring current) or external heating by solar or IR radiation. The time constant is a measure of the sensor's thermal mass and its ability to change temperature rapidly with ambient temperature changes. In the lower stratosphere (below 10 to 20 mb) and in the troposphere the heat transfer to and from the sensor is by convection so it is a function of atmospheric density and sonde fall velocity. Sample 43-mil glass bead thermisters have been received from YSI/VECO for evaluation.

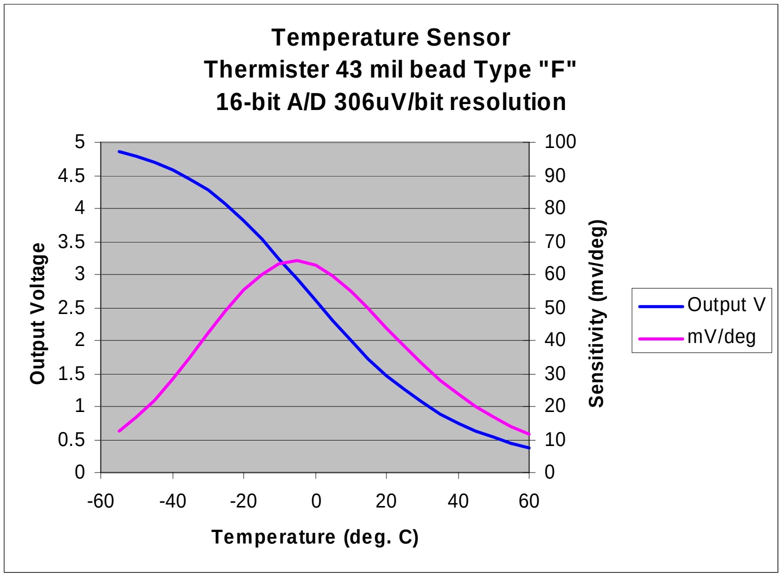

Figure 5 Temperature Sensitivity of Thermister

Remote control of the sonde

A team of CU engineering students working on Driftsonde as there senior project developed a method to remotely control the sondes from the gondola main electronics using a lowcost RF wireless system. The control of the sonde is required to turn the sonde power ON/OFF and release the sondes from the gondola. The system used in the past required 5 printed circuit boards, each 2.5"x 22" and only had the capacity for 23 sondes. A wireless system eliminates electrical limitaions to the number of sondes that can be carried by the Driftsonde gondola. There was also a large wiring hardness between the upper and lower portion of the gondola, both circuit boards and wiring hardness can be eliminated. By using a wireless approach to control the sonde, this will significantly simplify the production of the driftsonde gondola package electronics, reduce weight and assembly costs.

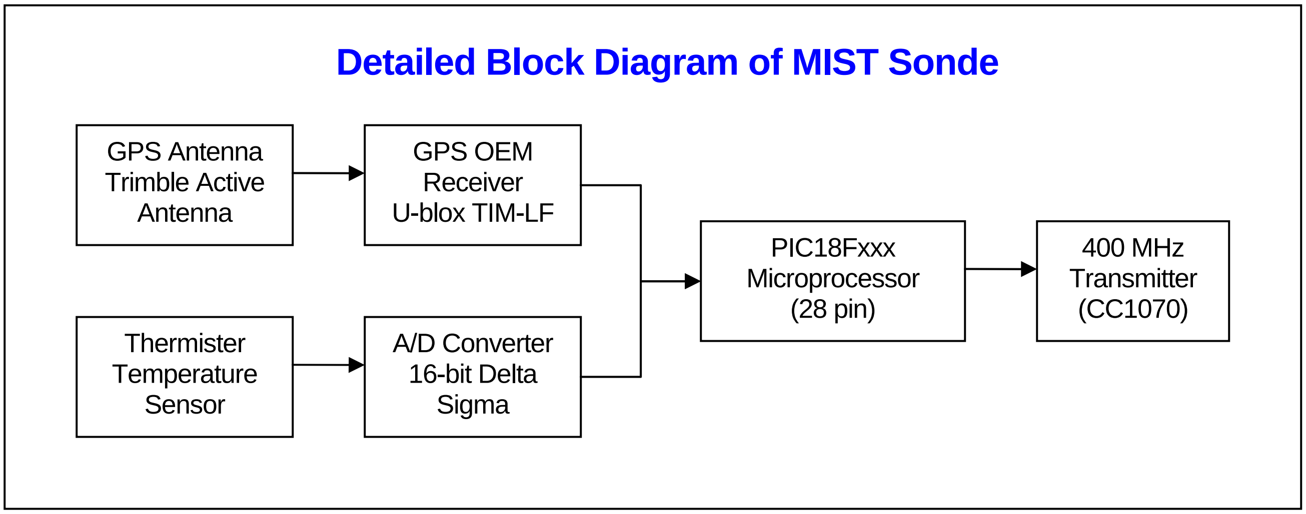

Figure 6 Updated block diagram of MIST Sonde

Printed Circuit Board (PCB) Design

The first version of the printed circuit board design is about to fabricated, below is the CAD view of the board. The dimensions of the board where the electronic components reside is 1.5" x 4.5" or 6.75 inches^2, this meets the original objective of developing a sonde the size of a credit card (typical area of a credit card is ~7 inches^2)

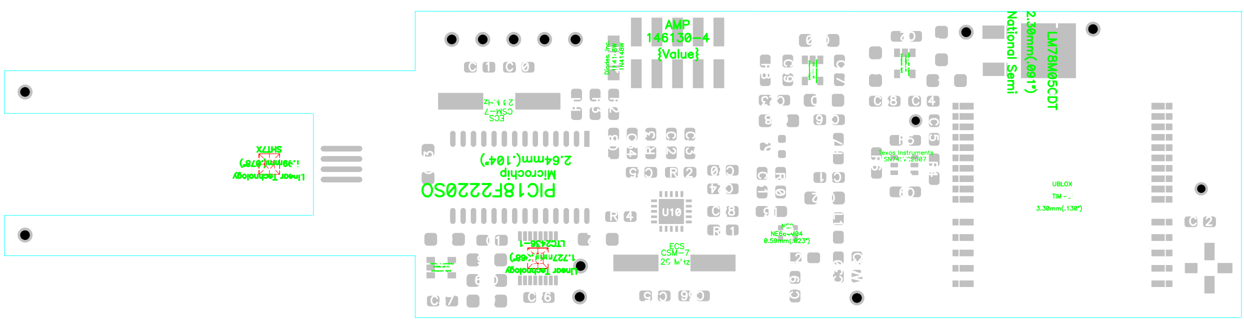

Figure 7 Preliminary Board Layout

Summary

The work that has been performed to date corresponds with the proposal for the first year with the emphasis on the development of a Miniature dropsonde for use in the Driftsonde gondola.