FIRST RESULTS OF THE GROUND-BASED MEASUREMENTS
OF THE IME-HF ANALYSER

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1. Introduction

The scientific instrument **IME-HF** is a high frequency electric field analyzer for the future French satellite **TARANIS** (**T**ool for the **A**nalysis of **R**adiation from light**NI**ngs and **S**prites) and is intended to study the little explored phenomena connected with Transient Luminous Events (TLEs) occurring above thunderstorms, as sprites, blue jets, and elves. The observations of these phenomena have been performed from the ground, from aircraft, balloons and from space. It was shown that these discharges can also be accompanied by terrestrial gamma ray flashes (TGFs), X-ray flashes and production of energetic electrons. Observations of electromagnetic radiation in the HF range from space can also provide us with an important piece of information about properties of lightning discharges, mainly in the case of the intra-cloud discharges, which are difficult to detect optically. The satellite will have polar orbit with an altitude of 700km and the mission lifetime should be 2 years. The launch is planned for the beginning of the year 2015.

2. The description of operational modes

The sensitivity of the HF receiver for the TARANIS satellite will be ~ 10 $nVm^{-1}Hz^{-1/2}$ at 10 MHz. The analyzed frequency band ranges from 30 kHz to 35 MHz. We use a sampling frequency of 80 MHz and a 12-bit resolution. There are two modes of operation:

1. In the survey mode 40 kbit/s of telemetry is available for the HF analyzer. Therefore a crucial point is a reliable detection and selection of interesting events. The selection is based on frequency filtering by a band of 12 filters and amplitude detection of the resulting signals to detect broadband radiation from lightning. Besides the selected parts ~300us of 80-MHz waveform recorded every ~15s, information of amplitude in the 12 frequency bands with a time resolution of 12ms, as well as regular snapshots (17 us of waveform each ~0.83s) will also be continuously transmitted to the ground to obtain a map of global distribution of intensity of HF waves.

2. The second mode of operation is the event mode. If an interesting event is detected onboard the satellite by any instrument, an event storage can be initiated by a satellite central unit. In this case, 128 Mbits of the HF analyzer data is recorded, stored and subsequently transmitted to the telemetry. 90% of the HF record is dedicated to the 80 MHz waveform storage (~120ms) and 10% for filter bank outputs (~1 s of data) with a time resolution of 12us. This total on-board memory capacity can be divided into up to 3 events of the waveform storage and 24 events of filter bank data.

3. The description of the design of the analyzer

IME - HF analyzer consists of a HF antenna with a preamplifier and a block of electronics. The analog part of the electronics includes amplifiers, anti-aliasing filter and the set of twelve band-pass filters with

amplifiers and RMS detectors. The antialiasing filter is the Tshebyshev passive low pass filter of the 13th order with a cuttoff frequency of 36MHz and a supression of more than 80dB at 50MHz. Every band pass filter is composed of a Butherword low pass filter of the 9th order and a Butherword high pass filter of the 9th order. The width of the frequency band of the filters is 3 MHz and the distance between the centres of the frequency bands of the neighbouring filters is 3 MHz as well. Thereby the whole frequency range is divided into twelve equal parts. The A/D converter ADC14C105, which is used in the fast path of the analyzer, is a high-performance CMOS analog-to-digital converter capable of converting analog input signals into 14-bit digital words at rates up to 105 Mega Samples Per Second. This converter uses a differential, pipelined architecture with the digital error correction and a very low power consumption. Twelve A/D convertors AD7450 are used for the conversion of the RMS values of the twelwe band pass filters. The AD7450 is a 12-bit, high-speed, low-power analog-to-digital converter with a serial output in a space-saving μ-SOIC8 package. The core of the digital part of the electronics is represented by the Xilinx Virtex4 FPGA , where the sampled and digitized signal is processed and saved. This FPGA is known for its exceptional levels of integration and high performance comparing to other one-time programmable technologies. It offers 4176 Kbits of RAM, 25280 slices and 56880 logic cells. The FPGA provides us with the control of analog-to-digital conversions, SDRAM operations and the communication between IME-HF analyzer and an attached computer.
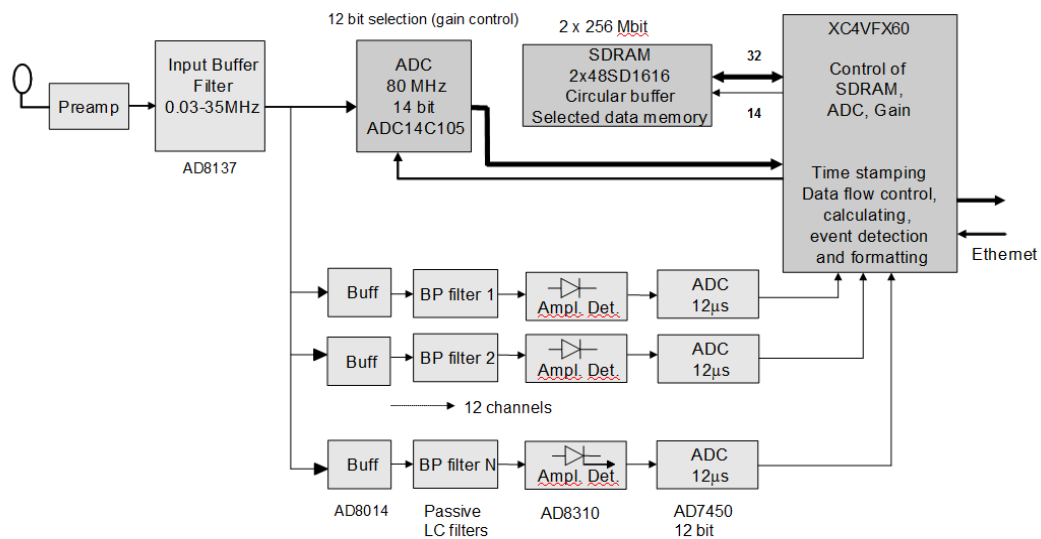

Fig.1 The functional scheme of the ground version of the HF analyzer

4.Conclusion

We finished the development and the manufacture of the first model of the HF analyzer, which will serve for coordinated ground-based measurements. We present its first results. We have tested the analyzer response to several types of known signals. During the continuous operation in our lab we have obtained interesting records of man-made electromagnetic noises. We also present measurements of real natural discharges.