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Software defined radio based embedded automatic identification system receiver for nano-satellites

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I. Introduction

The Automatic Identification System (AIS) is a maritime VHF communications system that provides information about ship identification, location, course, speed etc. to other ships and ground stations with goal of assisting with ship collision avoidance, security and vehicle tracking [1]. Ground stations have limited range and therefore are not only unable to gather information about ships far from coast, but require a large number of such stations to cover the entire coastline.

AIS messages are transmitted in two channels – A, 161.975 MHz and B, 162.025 MHz, using 9.6 kbps GMSK modulation over 25 or 12.5 kHz channels. To avoid message collisions a self-organizing time division multiple access (SOTDMA) scheme is used. The system uses the concept of 1 minute long time frames consisting of 2250 message slots [2].

A satellite based AIS receiver faces additional challenges when dealing not only with reduced signal-to-noise ratio, Doppler shift and environmental conditions, but also the possibility of packet collisions. As TDMA of AIS signals work on a local level but satellites have large coverage area, there is the possibility of ships that are not in view of each other to be both transmitting AIS messages on the same time slot. Collisions could also be caused by different path lengths making the adjacent time slot messages overlap. Although such situations would be rare in open seas, in areas with larger amounts of maritime traffic, which are of greater interest, the loss of data could be significant [3].

During the last decade there has been a push to implement space-based AIS receivers. Using nano-satellites for AIS monitoring provide data for vessel traffic in distant off-coast seas and give an insight into the collision of AIS messages in high-density traffic areas. One of the problems is to build the payload for such satellite - flexible and efficient AIS receiver system that meets low energy, size and weight requirements.

II. Solution

A. Hardware

Embedded platforms like Raspberry Pi and PandaBoard are a cheap alternative to traditional computing solutions with enough computing power to be suitable for advanced signal processing also meeting the requirements for low power usage in satellite systems. Easy software development and adaptation for the ARM architecture makes these boards an optimal solution for development platform.

FUNcube Dongle, developed as a part of AMSAT-UK's FUNcube satellite project, is a small software-defined radio receiver designed to make collecting of information from space available to anyone [4]. In a combination with a small embedded platform like Raspberry Pi it can be used as the main hardware for an embedded AIS receiver.

B. Software

GnuRadio, an open-source software development toolkit for software defined radio solutions in combination with Linux operating systems like Debian or Ångström and a control service application provide the software base for a nano-satellite system. It enables wide range of generic software defined radio solutions - easily adaptable and reconfigured even in an orbital environment. AIS messages can be decoded in real-time mode or in post-processing using Gr-ais module for GNUradio.

III. Results and Discussion

Embedded software defined radio based AIS receiver gives several advantages over traditional terrestrial AIS receivers used for most space purposes currently. Software-defined system can be used as a traditional real-time AIS receiver and also as a radio spectrum recorder *(Fig.1)* allowing the captured data to be decoded in post-processing. This enables implementation of advanced signal processing algorithms to deal with Doppler shift, environmental conditions and packet collisions.

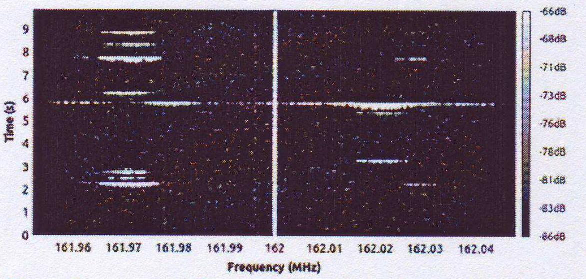

Fig. 1. Spectrum of AIS messages in the A (left) and B (right) channels captured with FUNcube Dongle

IV. Acknowledgements

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V. References

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