Satellite Based Ais (Automatic Recognition System) Front-End Receiver for Ships

K Muthulakshmi, S.Nithya Devi, N.Archana

Abstract-Automatic Recognition System (AIS) plays an important role in tracking maritime vessels and ships. AIS is an inexpensive low power wireless sensor solution that used to clear up the complications of diagnose ships by maintain locations, course, speed and more pivotal ship datas with all other aquatic ships/vessels and vessel traffic assistance stations. The receiver architecture for Satellite based AIS (Automatic Recognition System) is described in this report. The receiver performance are substantiate in the existence of the classic satellite medium aspects. The proposed system is hence proven to provide accomplished performance to the noise, also delay spread, Doppler shift, and flexibility to avoid collisions of messages.

Keywords: Automatic Recognition System (AIS), Doppler shift, Delay spread, tracking maritime vessels.

I. INTRODUCTION

AIS is an ITU standardized system designed to improve the safety of ships. Ship equipped with AIS transponder continuously broadcasts navigational data to other ships and ground base stations. The proposed report designed the practical and theoretical functionals in shipborne AIS andcorresponding needs and constraint of gathering of AIS messages packets from satellites the scientific drawback listedout were:

- The time slot of gathering AIS pockets in message (deficient period of intermediary for the satellite recognition area);
- The huge amount of message_packets foot print of satellite antenna (VDL as detected by the satellite, reuse of the time periods);
- The complications of satellite AIS differentiating signals during AIS message_packets and communications from terrene activities within the satellite antenna footprint (coverage pattern).

This report on further studies shows the need for a special AIS message that is shortened in length (Message 27) and broadcast on appropriate coverage itinerary on 2 other frequencies when those frequencies are nominate.

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II. CONCEPT OF AIS

AIS are a comprehensive shipborne system objective of developing efficiency and security of exploration used to conserve the coastal surroundings

Its main objectives to expedite an adequate interchange of pockets delivery among boats and seashore areas.

Such a arrangement is construct to separately range between the 40 nanometer. AIS-equipped boats or ships systematically transferred short length TDMA pockets of Messages including boats/ships recognition, areas, speed, course, and further status.

The adjacent AIS receivers, on board ships or shore services identify this information thus arranging a far-reaching picture the local surroundings, interdependent to the radar instruction.

The widerange applications in AIS incorporate diagnose of goals and attainment of such arrangement and obtaining locations modernize locations of ships open sea at the appraise of twice/day, and even once every hour.

III. CONCEPT OF S-AIS

An S-AIS system is a way of obtaining a widearea coverage appreciate match further the precondition of security exploration in monitoring.

The localization of boats/ships accomplish consistently grant the formation of a real-world data collections of ship locations. However, a satellite arrangement defines various feasibility issues and working challenges. LEO sequence of limited size of satellites is commonly pretended for widecoverage, with corresponding elevation ranging between 600km to 1000km. From such an elevation and beam width commonplace on-board VHFantennas, the satellite farmland of view (FoV) interval a few 1000s of nauticalmiles. The major problems considered is the gathering of informations caary from many AIS transmitted message_pockets in not to the AIS communication areas. Every areas autonomously coordinated SOTDMA design to reduce message collision possibility. However, the informations come from various areas/cells, also not in areas with depends other, accepted satellite, the possibility slot message_pockets collisions increases.

Analyses of the concept have shown that a microsatellite equipped with an AIS receiver can provide reliable services in sparsely trafficked waters, whereas for the heavily trafficked areas, interference betweenmessages causes the performance to decrease.

IV. CHALLENGES FACED BY S-AIS

Satellite depended AIS met extra practical threats this part not treated in the authentic/accurate AIS std. the current problems appear from the spaceborne activities of proposed system:

A. Message Collision

Emission AIS messages is synchronized to UTC, and the allocation of message slots is coordinated within each organized area.

A space-based AIS sensor will see many organized areas within its field of view as the satellite impression huge values than self-coordinated region to ordinary AIS region that around 40nm (nauticalmiles), the possibility of simultaneous reception of AIS messages arises as shown in Fig.1. The content of simultaneously received AIS messages, referred to as coinciding transmissions, will be lost.

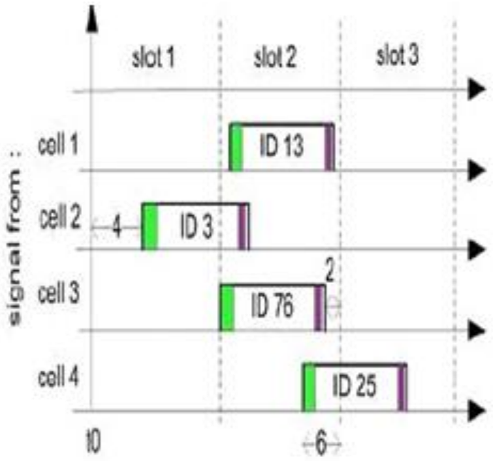

Fig.1 Depiction of message collision from different cells or organized areas

B. Path delay

The length carried by AIS messages_pockets constructed to meet with algorithmic propagation delaytime in messages_pockets from various boats within 2ms. Path timedelays barge and shuttle varied, based on barge station altitude and on the maximum antenna footstep.

There are two possible mechanisms for coinciding transmissions:

- The AIS messages are sent in the same message slot from different organized areas.
- The AIS messages are sent in different message slots from different organized areas, but are received simultaneously due to different signal path lengths.

The AIS standard uses a distance delay buffer of 12 bits in the AIS messages to prevent overlap between messages that are sent in adjacent timeslots. With a bit rate of 9600 bit/s, this translates to a slant path distance range of around 202 nm.

Slant length = (12 bits/9600 bits/s) * 3 .108 m/s = 375 Km ≈ 202 nm

For a nadir-pointing AIS sensor at 600 km altitude this translates into a ground range of 394 nm relative to nadir, as shown in Fig.2. This means that for swath widths up to about 800 nm only the first mechanism for coinciding transmissions is effective.

For swath widths larger than 800 nm the second mechanism for coinciding transmissions comes into play. consequence in overtaking the intermediary timedelay addressed outbreak disseminate in various hubs of the TDMA messgeframes (Fig.1) can strike.

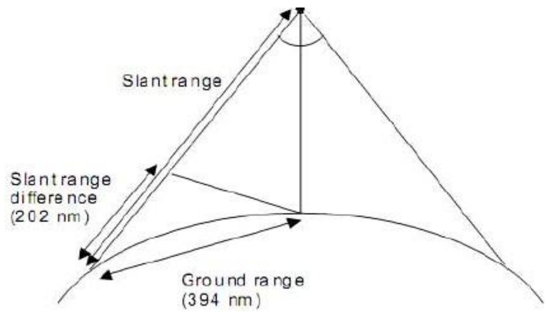

Fig.2 Geometry showing the relation between the slant range difference and the corresponding ground range for an AIS sensor at 600 km altitude.

C. Low SNR values

The higher message_pockets losses and based to circumstance antenna receiver gains, SNR during 20dB to 0dB values are expected and nominal.

D. Multipath and atmospheric attenuation:

This is imperceptible at VHF values. The various_path component parameters are (Limited) impact at very low altitude angle degree the consideration on the sea expanse.

E. Faraday rotation

The linearly contradictory movement reached ionosphere have various broadcast angle time of leaves. This broadcast rotation angle majorly reliant on spectrum, altitude angle, geo-magnetic density of flux and electron, in ionosphere. When the existence of a circularly- broadcasted (SRA) satellite receive antenna, dependable 3dB loss is current accepting the aimlessly revolve diagonally contradictory VHF wave as broadcasted by the boats antenna.

F. Doppler Effect

The Doppler frequency shift is a function of relative velocity between transmitter and receiver. In the case of AIS-sat, the ship's velocity is small compared to the satellite, such that the Doppler shift can be calculated as:

$\Delta f = / \lambda$

Where, λ = c/f (=1.86m) is the wavelength of the original AIS-signal and vr is the component of the satellite velocity directed toward the ship. v_r will vary with elevation and azimuth angle from zero ($\Delta f = 0$) when the ship's free line of sight to the satellite is orthogonal to the satellite's velocity vector and to maximum with the ship placed just within the satellite's local horizon and the free line of sight parallel to the to the satellite's velocity vector.

In order to calculate, the velocity of the satellite in orbit has to be calculated. From above, we have the period of AIS-sat.

$$T = 5801.1s$$

The circumference of the orbit is $2\pi \cdot (6378 + 600) = 43844$km so the velocity of the satellite in orbit is

$$v_S = 43844/5801.1 = 7.56 \text{ km/s}$$

The component of velocity toward an observer in the plane of orbit as the satellite appears over the horizon is given by = cosθ .cosφ where θ is the angle between the satellite velocity vector and the direction of the ship at the satellite and phi is the azimuth angle.

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$$\theta = \pi/2 - \theta_{sat}$$

Thus, becomes

= cosθ =sin(θ_{sat}) And finally, the Doppler shift

$\Delta f = v_r / \lambda$

Fig.3 shows the MATLAB simulation of the typical distribution of the absolute Doppler shift when in presence of a 600 Km altitude LEO satellite and uniform ship distribution within the coverage.

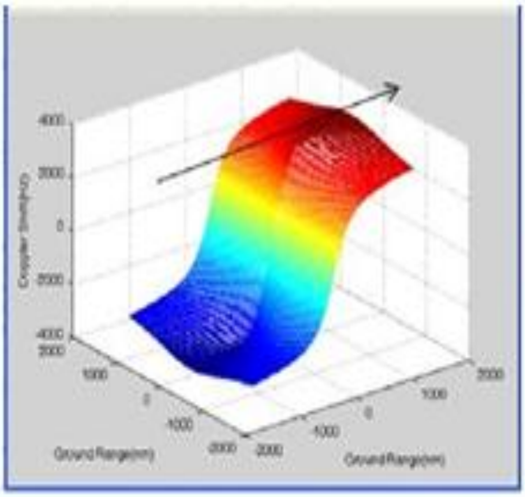


Fig.3 Doppler shift distribution within the satellite coverage. Satellite speed vector along the arrow direction

Fig.4 shows some hyperbolic contour lines of the Doppler shift within the FOV of the satellite. The maximum and Doppler shifts are

= ±3.71kHz.

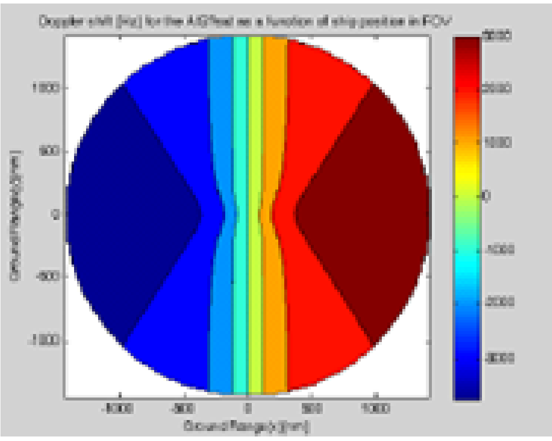


Fig.4 Doppler shift for ships in the FOV

G. Ais Receiver For Satellite Reception

Fig.5 shows a detailed block diagram of the proposed AIS receiver for satellite reception. The signal received from the antenna is first processed by an analog RF front end whose detailed description is out of the scope of this TDP but it basically consists of a low- noise amplifier followed by a frequency down-conversion and filtering to reach the baseband configurations. The A/D converters provide the digitized samples of the IF signal to the baseband. Sampling rate of A/D converter is chosen in such a way that number of samples per bit (NSPB) is 10. This sampling rate is considered adequate for the next processing including the timing recovery. The samples are then stored in a buffer. From the buffer, signal samples are read sequentially and given as input to the filter bank and subsequently to the demodulator.

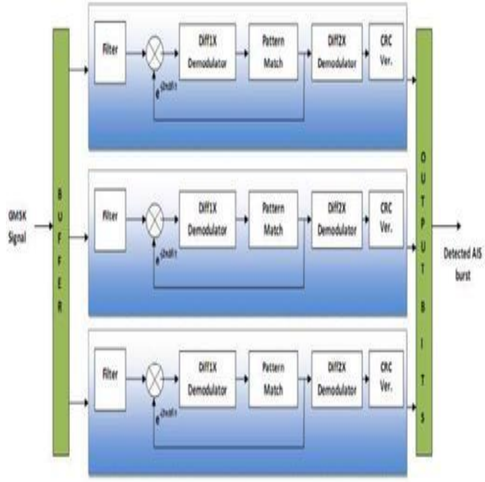


Fig.5 Architectural block diagram of the proposed AIS satellite receiver

V. RESULT AND DISCUSSION

From the difficulties of the proposed procedural methods, the satellite signal corresponding datas gathered signal by Satellite using network simulators tool. The height rotational receiving area satellite is defined by 1000 km and suitable angle in 55 degree. Simulations designed to analysis performance by different category of 3 signals for locations. Space based reception introduces a large Doppler frequency shift of the received signals, which is in the range of ±3.8 kHz due to the satellite speed. Another concern is interference due to the likely large satellite antenna footprints and the possibility of more than two AIS bursts from different transmitters colliding at the satellite. To cope with this issue, the receiver is implemented with a filter bank and three branches in parallel. The "filter bank" exploits the frequency diversity generated by the Doppler spread. This is illustrated in the Fig.6 where the overall AIS channel band is divided into 3 overlapping sub-bands each of bandwidth equivalent to the signal bit rate R , and staggered by 0.3Rb. In particular, each branch of the receiver is specifically designed to process only one slice of the AIS channel and to achieve the target performance within that slice.

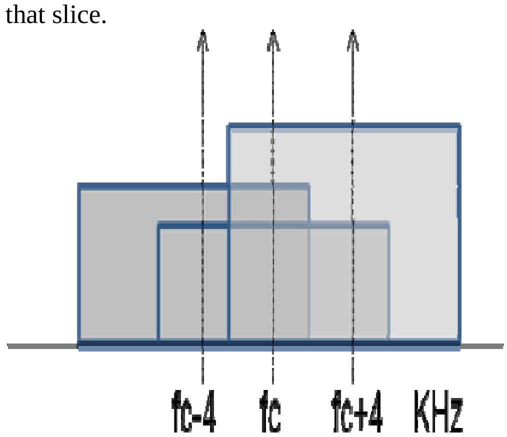
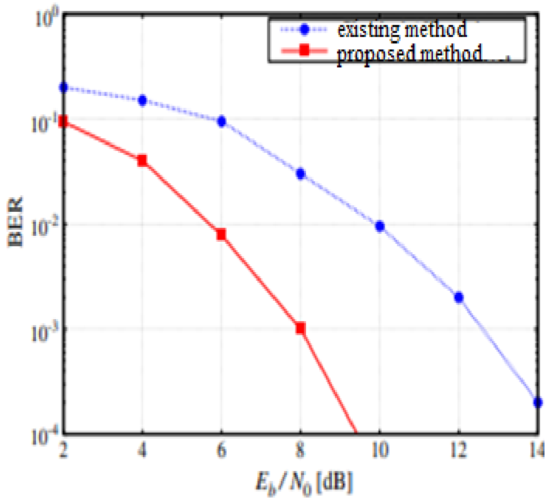


Fig.6 Filter bank

Each branch of the receiver takes as an input the samples from the buffer and then carries out the basic synchronization and detection functions.

In particular it consists of Acquisition block, the non-coherent detector block (NCD) and the CRC verification block (CV).



The information bits of a length-N burst are non-return-to-zero-and-inverted (NRZI) encoded into a sequence of symbols, called bipolar symbols. The differential encoder state ultimately determines the composite sign of all transmitted symbols in a burst, and is not specified in the AIS standard. After differential encoding, the encoded symbols are then GMSK modulated. This modulation process can be thought of in three steps: instantaneous frequency modulation, phase modulation and phase to I/Q mapping.

Implementation of differential detection in Gaussian signal accommodates large Doppler range, is robust to sudden anomalous changes in instantaneous phase or frequency and is insensitive to and is amenable to efficient implementation.

VI. CONCLUSION

Satellite-based AIS has to face additional technical challenges as compared to the original terrestrial AIS standard. These new issues arise due to the space borne nature of the new system. These include large number of cells in satellite field of vision and uncoordinated messages from ships belonging to different SOTDMA cells leading to message collision, all the cells are operating with common frequency, high carrier Doppler, lower signal-to-noise ratio and propagation delay larger than distance delay buffer. These technical issues and challenges are overcome in the new receiver architecture proposed in this paper.

REFERENCES

1. Recommendation ITU-R M.1371-1: Technical Characteristics for a Universal Shipborne Identification System using Time Division Multiple Access in the VHF Maritime Mobile Band, ITU 1998- 2001.
2. Miguel A. Cervera and Alberto Ginesi : Satellite based AIS system Study, 26th International Communications Satellite Systems Conference, 10-12 June 2008, San Diego, California
3. HØYE Gudrun : Observation Modeling and Detection Probability for Space-Based AIS Reception FFI/RAPPORT-2004/04390
4. Ole Fredrik Haakonsen Dahl : Space-Based AIS Receiver for Maritime Traffic Monitoring Using Interference Cancellation – Thesis report :Norwegian University of Science and Technology Department of Electronics and Telecommunications
5. Miguel A. Cervera, Alberto Ginesi and Knut Eckstein : Satellite-based vessel Automatic Identification System:A feasibility and performance analysis, International Journal of Satellite Communication Network. 2011; 29:117–142
6. Ginesi A, Burzigotti P. Advanced receiver design for satellite-based AIS signal detection. ESA Technical Report, 2008.
7. Pratt T, Bostian C, Allnutt J (2003): Satellite Communications John Wiley & Sons, 2003.
8. James E. Hicks, James S. Clark, Jeffrey Stocker, Gregory S. Mitchell, Peter Wyckoff james.hicks@aero.org: AIS / GMSK Receiver on FPGA Platform for Satellite Application, The Aerospace Corporation, 15049 Conference
9. M. G. Souissi, K. Grati, A. Ghazel and A. Kouki, "Software Efficient Implementation of GMSK Modem for an Automatic Identification System Transceiver," in Canadian
10. Conference on Electrical and Computer Engineering, Niagara Falls, 2008. National Marine Electronics Association, NMEA 0183: Standard For Interfacing Marine Electronic Devices, 3.01 ed., Severna Park, Maryland: National Marine Electronics Association, 2002.
11. Swedish Maritime Administration, "Automatic Identification System," Swedish Maritime Administration, Feburary 2004.
12. B. Sklar, Digital Communications Fundamentals and Applications, 2nd ed., R. Kernan, Ed., Upper Saddle River, New Jersey: Bernard Goodwin, 2003. L. Gao and J. Liu, "Design of Dual- Channel AIS Digital Receiver," in International Conference on Instrumentation & Measurement, Computer, Communication and Control, Heilongjiang, 2012.
13. A.N. Bishop, B. Fidan, K. Doˇganc , ay, B. D. O. Anderson, and P.N. Pathirana, "Exploiting geometry for improved hybrid AOA/TDOA-based localization," Signal Processing, vol. 88, no.7, pp. 1775–1791, 2008.
14. G.-H. Zhu, D.-Z. Feng, H. Xie, and Y. Zhou, "An approximately efficient bi-iterative method for source position and velocity estimation using TDOA and FDOA measurements," Signal Processing, vol. 125, pp. 110–121, 2016.
15. Y. H. Kim, D. G. Kim, and J. W. Han, "Analysis of sensor emitter geometry for emitter localization using TDOA and FDOA measurements," IET Radar, Sonar & Navigation, vol. 11, pp. 341–349, 2017.
16. Y. Wang and Y. Wu, "An efficient semidefinite relaxation algorithm for moving source localization using TDOA and FDOA measurements," IEEE Communications Letters, vol. 21, no. 1, pp. 80–83, 2017.
17. L.Hong-Tao and K. Feng-Ju, "Tracking UUV based on interacting multiple model unscented particle filter with multi-sensor information fusion," Optik—International Journal for Light and Electron Optics, vol. 126, no. 24, pp. 5067– 5073, 2015.
18. R. Tou and J. Zhang, "IMM approach to state estimation for systems with delayed measurements," IET Signal Processing, vol. 10, no. 7, pp. 752– 757, 2016.
19. S. Kay, "A fast and accurate single frequency estimator," IEEE Transactions on Signal Processing, vol. 37, no. 12, pp. 1987–1990, 1989.
20. M. Morelli and U. Mengali, "Joint frequency and timing recovery for MSK-type modulation," IEEE Transactions on Communications, vol. 47, no. 6, pp. 938–946, 1999.