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Application Research of H-field Antenna in Enhanced Loran

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Abstract—Enhanced Loran-C is a Loran system that applies the latest receiver and H-field antennas technology to meet the requirement as backup and complement to GNSS. Loran receiver performance is dependent upon antenna performance, and technology has mainly advanced in H-field antennas.the situation of some research of the H-field antennas overseas is presented in the paper,and as a solution ,a design of H-field antenna is presented, and procedure of the inelligent H-field antenna is described, Some experiments and demonstration are made to research the performance of the antenna,the data result of experiments is analyzed and conclusion is made that it's advanteges over the electric antenna by contrast.

Keywords-Loran-c;EnhancedLoran,H-field antenna; E-field antenna; SNR;

1. Introduction

The antenna is used to provide the signal for receiver by induction,which can be individed into the eletric antenna and the magnetic antenna or called E-field and H-field antenna. The eletric antenna induce electric field of electromagnetic wave and the magnetic antenna induce the magnetic field.Most of the current loran-c receiver uses the eletric antenna to induce the signal,which has some defects. In the paper the H-field antenna technology is introduced to solve some problem in E-field antennas,specially in the backgroud of Enhanced Loran-C ,the H-field antennas will be the solution to the aviation application and can be the part of combination of GNSS and e-Loran.

2. Legacy Loran and Enhanced Loran

Loran,which means "Long Range Navigation", is a terrestrial, regional radio navigation system that uses ground-based transmitters[1]. Wide usage of Loran started in the 1950s with Loran-C, which was developed by the U.S Navy and U.S. Coast Guard. The system used short phase-coherent pulses with a carrier frequency centred on 100 kHz, and a bandwidth range from 90-110 kHz[2]. Loran-C was also implemented in many areas including North America (USA and Canada), North-West European area (France, Netherlands, Norway,Denmark, Germany and Ireland) and the Far-East area(Russia, China, Korea and Japan).

Today, Loran-C development is in the state of being embarrassed with the introduction of GNSS like GPS GLONASS,GALILEO and COMPASS. Given that Loran-C could not match the performance of GPS, the U.S. Department of Transportation announced its intention to cease Loran-C support by the year 2000. In the late 1990's it became clear that GNSS, primarily GPS, needed a backup due to its susceptibility to jamming

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(Volpe report, issued in September 2001). The U.S. Congress, which recognized Loran's value as a GPS backup, provided the Loran-C Recapitalization Project (LRP) with approximately $120m[3].LRP work is performed under an interagency agreement between the Federal Aviation Administration (FAA) and the USCG. New enhanced Loran-C, known as eLoran, is is a Loran system that incorporates the latest receiver, H-field antennas, and transmission system technology to enable Loran to serve as a backup and complement to global navigation satellite systems . This new technology provides substantially enhanced performance beyond what was possible with Loran-C, eLoran's predecessor. For example, it is now possible to obtain absolute accuracies of 8-20 meters while the FAA requirement is integrity of 99.99999% using eLoran for harbor entrance and approach[4]. Similarly, eLoran can function as a highly accurate frequency source and as an independent source of coordinated universal time (UTC). In 2010, the U.S. Coast Guard which is the governor of Loran-C in North America officially announced its ceasing Loran-C support in USA. But some differently, Chinese Loran-C still has potential in some applications specially in timing service, serving as a viable backup to GNSS for precision time and frequency transfer[1]

3. H-field antnna applied in Eloran

Loran receiver performance is dependent upon antenna performance, and technology has mainly advanced in magnetic, or H-field, antennas. In the late 1990s, Ohio University performed some tests on receivers[5]. These tests results improved that H-field antennas were immune to P-static interference (precipitation static) that can occur on an airplane during stormy weather[6].Under these conditions, ionized particles accumulate on an airplane's skin, often generating potentials in the 15,000 – 45,000 volt range. The spontaneous discharge of these high potentials disrupts reception by Loran E-field antennas, thus H-field antennas have a distinct advantage in aviation.In addition, H-field antennas offer several advantages over E-field antennas in virtually all Loran applications (i.e. aviation, marine, terrestrial, and timing). These advantages provided an important impetus to proceed with advancing H-field technology. several other important advantages of H-field antennas is followed.[7] Firstly,H-field antennas have an 3 dB SNR advantage over E-field antennas,which can be significant, specially in marginal workaround. Secondly ,H-field antennas decrease ECD values, so identification of the correct zero crossing is more rapid and reliable. Thirdly H-field antennas require no grounding, which means H-field antennas are easier to install and will operate closer to the ground. Finally and important, H-field antennas are small, and can be combined with GPS antennas within a single enclosure or radome. they can be integrated with a GPS antenna into a single unit,described in figure1,it is shown a mechanical drawing of a combined GPS and Loran H-field antenna, as integrated within a single radome for avionics testing. a GPS microstrip patch antenna is positioned in the center of a Loran H-field antenna. The dimensions of the H-field are 130mm x 130mm x 50mm. Tests on a combined GPS/Loran prototype antenna have demonstrated that neither GPS nor Loran reception is compromised by the presence of the other antenna.

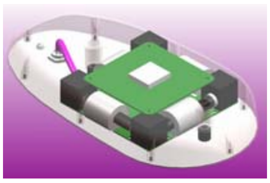

Fig.1.The integrated antenna of Loran-C H-field and GPS

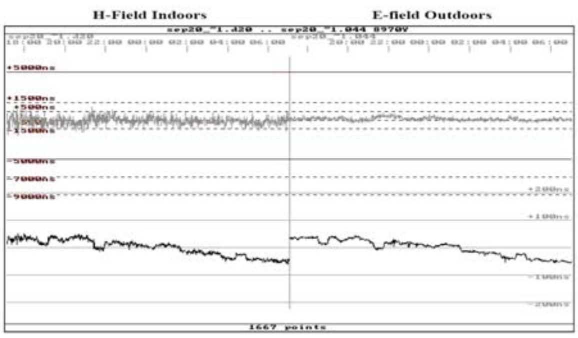

Fig.2. Comparison of ECDs (top) and TDs (bottom) from H-field antenna located indoors versus E-fieldantenna located on Locus' roof.

Figure 2 presents some H-field antenna test done 2000[6], and illustrates envelope-to-cycle distortions (ECD)and time differences (TD) taken simultaneously from a prototype H-field antenna and an E-field antenna. The H-field antenna was located indoors (by a window) and the E-field was on the roof of Locus' office building. Data acquired simultaneously using identical SatMate receivers. Note the Cs clock drift and 20 nS timing jumps. Cs clocks and transmitter control electronics are currently being upgraded by the USCG, but still show these jumps. the results show the data from the indoor H-field are noisier but quite similar to the outdoor E-field.

Figure3[6] shows the Simultaneous SNR (top) and ECD (bottom) data from E-field and H-field antennas taken during dynamic field trials in 2001 using identical, all-in-view DSP receivers. Note higher signal levels and SNRs with H-field, as well as lower ECDs[6].

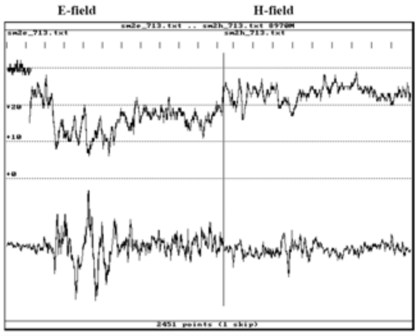

Fig.3. The SNR (top) and ECD (bottom) data from E-field and H-field antennas

4. A Solution of H-field Antenna

4.1. The Unit of the H-field Antenna

The structure of the unit is described as figure4 followed[8]. There are four components Which detect the directiong of the loran-c wave arriving by the precision of 7°. The signal induced in antenna is flew to the module of Filter and Amplify,which filter and amplify the signal in loran-c band. The output and control module is the interface beweent the antenna unit and the receiver,which achieve the impedance matching and signal output,synchronously convert the control signal input to the instruction which indicate the antenna to synthesize and switch.

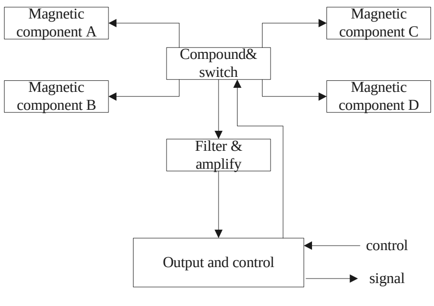

Fig.4. The sketch map of the magnetic unit

4.2. Experiment about the Performance of the Antenna

1) *The brief of the experiment*

There are two places for the experiment,one place is aroud NanHui District,ShangHai and the other point is aroud Raoping,GuangDong province. We use the same device of the intellegent magnetic antenna to receive the loran-c signal and record the result,which is compared with the result of the equipment of the electric antenna,and experiment time is choosed the sunny day and rainy day respective.It is emphasized that two kind of antenna use the same receiver.

2) *Date of the experiment*

Fig.5. The real-time results of electric antenna (upside) and H-field antenna(downside)

Fig5 is presented the real-time result of the experiments at a point of NanHui district in April 2 and June 19[9].

The upper map means the result of the receiver by electric antenna and the below map means the result of the magnetic antenna. It present the SNR of signal induced by magnetic is -15db(20:24:26,April 2) and -2db(06:19:46,June 19),and the SNR of elcetric antenna is -19db(20:24:08,April 2) and -7db(06:19:56,June 19).

TABLE I. MEAN DATE FOR HOURS IN NANHUI ON APRIL2

TD(XuanCheng---- RaoPing) TIME :(2007-4-20 日 01:00—12:00) Weather: sunny								
hour	Mean intensity(dB)		Mean SNR(dB)		Mean ECD(μs)		Mean TD(μs)	
	Electric antenna	Magnic antenna	Electric antenna	Magnic antenna	Electric antenna	Magnic antenna	Electric antenna	Magnic antenna
1	57	62	-17	-14	-50	-50	16 977.953	16 977.758
2	53	61	-17	-13	-50	-50	16 977.961	16 957.749
3	53	62	-16	-12	-50	-50	16 977.008	16 977.669
4	54	61	-12	-9	-39	-50	16 977.967	16 977.638
5	54	64	-8	-4	-20	-50	16 978.049	16977.518
6	50	63	-7	-4	-24	-50	16 958.009	16 977.535
7	55	61	-9	-3	-34	-50	16 977.949	16 977.453
8	56	61	-10	-5	-31	-50	16 978.00	16 977.450
9	56	61	-10	-7	-24	-50	16 978.012	16 977.462
10	55	61	-9	-6	-18	-50	16 977.839	16 977.470
11	55	61	-9	-6	-16	-50	16 978.049	16 977.468
12	55	61	-10	-6	-21	-50	16 977.995	16 977.460

TABLE II. MEAN DATE FOR HOURS IN NANHUI ON JUNE 19

TD(XuanCheng---- RaoPing) TIME :(2007-6-19, 01:00—12:00) weather: rainy								
Hour	Mean intensity(dB)		Mean SNR(dB)		Mean ECD(μs)		Mean TD(μs)	
	Electric antenna	Magnic antenna	Electric antenna	Magnic antenna	Electric antenna	Magnic antenna	Electric antenna	Magnic antenna
1	53	61	-18	-15	-37	-38	15 857.740	15 857.603
2	48	60	-18	-16	-44	-45	15 857.514	15 857.589
3	54	60	-17	-15	-47	-50	15 858.134	15 857.541
4	55	61	-14	-12	-37	-50	15 858.030	15 857.598
5	55	61	-10	-5	-22	-50	15 857.973	15 857.536
6	50	63	-9	-4	-28	-45	15 857.825	15 857.462
7	55	62	-10	-4	-30	-48	15 857.980	15 857.440
8	54	62	-11	-5	-24	-48	15857.997	15 857.392
9	55	62	-8	-6	-15	-47	15858.002	15 857.372
10	56	62	-7	-6	-14	-48	15858.095	15 857.358
11	55	62	-8	-6	-12	-50	15 858.044	15 857.327
12	56	61	-7	-6	-07	-50	15 858.053	15 857.316

These two tables describe the mean data of the result of 12hours experiment[9]. Table 1 record the data at some point in NanHui district on April 2 in 2007. The mean data of 12hours was recorded,including the

SNR,ECD,TD and signal intensity. The other table 2 record data on June19 in 2007. it is reminded that the weathe of two day is sunny and rainy,which is tested the performance in different weather.

4.3. The Analyse of the Date of Experiments

The experiments made to show the continul performance of two kinds of antenna.it can be seen during 12-hours continuous experiment ,the mean data of signa intensity and SNR is compared between the two antenna.the result show that the signa intensity of magnetic antenna exceed the signal of electric antenna by 5-8db, and the data of SNR is 3-5db.

The performance affected by the rainy weather is also tested in experiment. The result show that ,the rainy weather would depress the performance of the electric antenna by 1-5db of signal intensity ,while the magnetic antenna is uninfluenced by weather in the data of signal intensity.

5. Conclusion

The results from these and many other tests strongly suggested that an H-field antenna is one of the key technology for enhanced loran ,which could be combined with a modern,DSP-based Loran receiver to provide a higher level than the legacy loran-C system performance. taking advantage of important H-field antenna characteristics, such as immunity to P-static interference and opportunities for significant size reduction,e-Loran can be used in the application of aviation and timing and so on,to be the backup of GNSS.

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