Modified L-type eLoran transmitting Antenna for Co-location with an AM Antenna

Hanni Koo and Sangwook Nam
Institute of New Media Communication (INMC), School of Electrical and Computer Engineering,
Seoul National University, Seoul 151-742, Korea
hnkoo@ael.snu.ac.kr

***Abstract* - The modified L-type eLoran (enhanced Long Range Navigation) transmitting antenna is proposed for co-location with an AM transmitting antenna in a limited area. To compensate for the loading effect, the inverted L-type antenna is modified by adding the umbrella-type loading. The AM antenna is co-located with the radiator part and the loading part of the proposed antenna. The simulation results of the eLoran antenna show 1.4 kHz bandwidth and 32.5% radiation efficiency. Also, the validity of the co-location between the AM antenna and the eLoran antenna is verified through the simulation results of the radiation pattern and the antenna coupling. The proposed eLoran antenna can be used with the AM antenna in the same area.**

***Index Terms* — eLoran transmitting antenna, modified L-type, umbrella-type loading, co-location, AM antenna**

1. Introduction

Global Positioning System (GPS) technology is known to be vulnerable to both intentional and unintentional jamming. North Korea has tried to jam GPS signals across the South Korean border since 2010. In 2012, jamming signals sent by the North forced commercial flights to turn off their GPS. As an alternative, eLoran (enhanced Long Range Navigation) is known as an excellent backup system for GPS [1]. However, the eLoran transmitting antenna takes up a very large area. For example, the Wildwood eLoran antenna in the USA has a radial ground radius of 190 m [2], [3]. It is difficult to find eLoran transmitting station in South Korea, due to limited land space and the abundance of mountains and buildings. To solve this problem, an eLoran system is utilized with the existing AM transmitting site.

In this paper, the modified L-type eLoran transmitting antenna for co-location with an AM antenna is presented. The inverted L and umbrella-type antenna provide a general example of top-loading [4] – [6]. However, it is difficult to engage in top-loading by using inverted L or umbrella-type antenna solely because of the limited area. To compensate for the loading effect, the inverted L-type antenna is modified by adding the umbrella-type loading. The AM antenna is co-located with the radiator part and the loading part of the proposed antenna. The simulation results showed that the bandwidth of the eLoran antenna is 1.4 kHz. The radiation patterns of the AM antenna co-located with the eLoran antenna retained its respective shape compared with the results AM antenna is simulated alone. The coupling between the AM and eLoran antenna is –39.53 dB at 100 kHz and –31.3 dB at 1053 kHz, respectively. The proposed antenna can be used with the AM antenna in the same area.

2. eLoran Antenna Design

Fig. 1. shows the AM transmitting site in Kimpo, South Korea, which is limited to the red line. The AM antenna consists 4 monopoles whose interval is 50 m. The size of the eLoran antenna is determined by the remainder of the AM transmitter site. Radial ground is considered; the radius is 75 m and the number of the radial ground is set to 120. The eLoran is transmitted in an LF band at a center frequency of 100 kHz. The height of the proposed eLoran antenna is 150 m, and its electrical length is much less than a quarter wave. To maximize the electrical length of the antenna, L-type and umbrella-type loading is proposed. The proposed antenna is divided into two parts: the radiator and the umbrella-type load that is separated from the radial ground by an insulator. The number of the top loading elements (TLEs) is set to 24, each of which has 0.01 m diameter radials that extend at an angle of 26.57°. The two separated parts are connected to each other by loading a wire across the AM antenna, as shown in Fig. 2, and the length of the loading wire is 260 m. A perfect conductor is used for the antenna, and the conductivity of the ground is considered: ITU-R P.832-2 indicates a ground conductivity of 3 mS/m in Kimpo, South Korea [7]. The simulation shows the input impedance to be 5.9–29 Ohms, and the antenna needs to be tuned to resonance by adding an additional 48 uH. The simulated return loss of the proposed antenna is plotted in Fig. 3. It is shown that 3 dB bandwidth from center frequency is 1.4 kHz. The radiation pattern is omnidirectional, and the efficiency is 32.5% at 100 kHz.

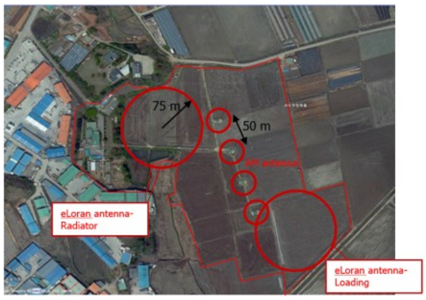


Fig. 1. Location of the eLoran and AM transmitter antenna in the AM transmitter site.

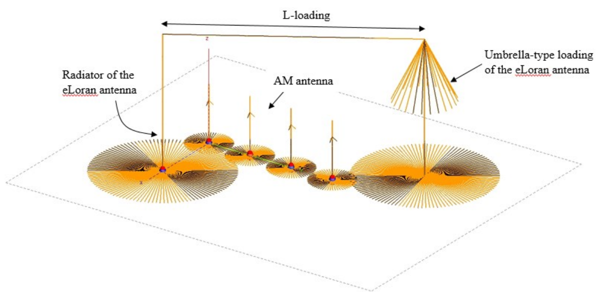


Fig. 2. Proposed eLoran antenna co-located with the AM antenna

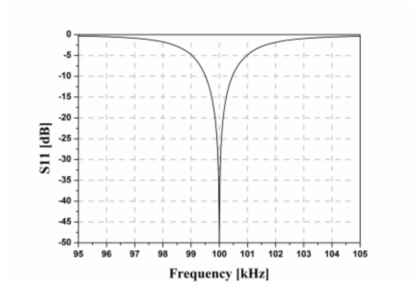
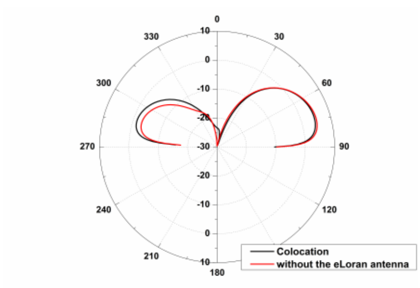


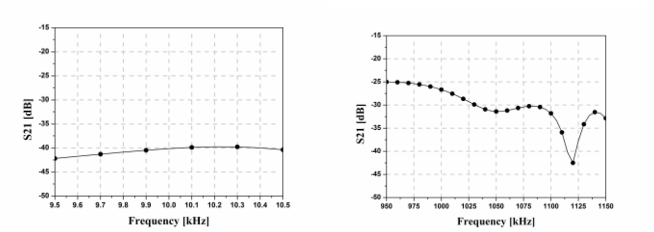
Fig. 3 Return loss of the proposed eLoran antenna, co-located with the AM antenna

(a) H-plane



(b) V-plane

Fig. 4. Radiation pattern of the AM antenna



(a) eLoran band (b)AM band

Fig. 5. Coupling between the eLoran and the AM antenna

3. AM Antenna interference

The antenna interference between the AM antenna and eLoran antenna is verified by considering the AM radiation pattern and the coupling. Simulation results were obtained by using FEKO, a commercial software tool.

(1) Radiation pattern

The AM transmitting antenna is operated as a Yagi-Uda antenna, which consists of one radiator, one reflector, and two directors. Fig. 4 shows a comparison of the radiation pattern of the AM antenna at 1053 kHz and the operating frequency of the AM antenna. The red line signifies the radiation pattern without the eLoran antenna, and the black line represents the radiation pattern where co-location is considered. The level of antenna interference is reasonable because the two patterns are similar.

(2) Coupling

Antenna coupling between the AM and the eLoran antenna at the eLoran band and the AM band is shown in Fig. 5. The coupling is –39.53 dB at 100 kHz and –31.3 dB at 1053 kHz, respectively.

4. Conclusion

The modified L-type eLoran transmitting antenna, co-located with the AM antenna, is proposed and simulated. The simulated results show that the bandwidth of the antenna is 1.4 kHz, and the efficiency is 32.5%. There is not much difference between the co-location and the simulated AM antenna radiation patterns alone. Coupling between AM and eLoran antenna is –39.53 dB at 100 kHz and –31.3 dB at 1053 kHz, respectively. This coupling is beneficial when the proposed antenna is applied to the narrow and limited site, as in the case of the AM transmitter.

Acknowledgements

This work was supported by the Brain Korea 21 Plus Project in 2016.

References

[1] Johnson, G. W., "An evaluation of eLoran as a backup to GPS," in *IEEE Conference on Technologies for Homeland Security*, May 2007, pp. 95—100.

[2] John Pinks., "Theoretical Evaluation Suitability of USCG LSU 625' TLM Loran Antenna at Wildwood, N.J. at 500 kHz for DRM transmission," *RTCM Paper 043-2011-SC123-085*., February 28, 2011.

[3] T. Hardy, and N. Limited, "Next generation LF transmitter technology for (e)Loran Systems," Nav08/ILA27 Conf. & Exhib., 2008.

[4] T. L. Simpson, "The theory of top-loaded antennas: Integral equations for the currents," *IEEE Trans. Antennas Propagat*., vol. AP-19, pp. 186–190, Mar. 1971.

[5] V. Trainotti and L. A. Dorado, "Short low and medium frequency antenna performance," *IEEE Antennas Propag. Mag*., vol. 47, pp. 66–90,

[6] Oct. 2005.T. E. Devaney, R.F. Hall, and W.E. Gustafson, Low-frequency top loaded antenna," *R&D Rep. 1381*, Navial Postgraduate School, California, 2 March 1987.

[7] ITU-R P.832-2 World Atlas of Ground Conductivities. 1999.