A NEW TYPE OF DIPOLE ANTENNAS WITH CRANK SECTIONS FOR DUAL-BAND ARRAYS

Kazushi NISHIZAWA, Hirokatsu OKEGAWA, Hiroyuki OHMINE and Takashi KATAGI
Mitsubishi Electric Corporation
5-1-1 Ofuna, Kamakura-shi, Kanagawa, 247-8501 Japan
Tel.: +81-467-41-2534, Fax.: +81-467-41-2519
E-mail: nissy@isl.melco.co.jp

1. Introduction

Multi-band array antennas using dipoles shared their aperture have been studied [1], [2]. The dipoles operating at lower bands (f_L dipoles) have a harmful effect to the dipoles operating at higher bands (f_H dipoles) in radiation patterns such as asymmetry and distortion. Because the f_L dipoles are longer than the f_H dipoles and are located above the f_H dipoles. This radiation pattern of distortion on f_H dipoles causes a spatial periodicity on the array aperture in relation to the element spacing of the f_L dipole. Therefore, such periodicity on the aperture results in grating lobes appearing in f_H operation.

In this paper, we propose a new design of f_L dipole for dual-band array antennas. This dipole includes crank sections that can suppress an undesired current caused by f_H dipoles. The principle of the operation of the crank section is explained and its efficiency to suppress the undesired current is indicated by a computer simulation. In addition, it is shown that grating lobes in an array antenna are suppressed by applying the new dipole for a dual-band array antenna.

2. Principle of the operation

Figure 1 shows the geometry of a dual-band array antenna composed of the f_L dipole and the f_H dipole. The upper element in this figure is the f_L dipole ended by a dummy, and the lower element is the f_H dipole, which is driven. The two dipoles are located over an infinite reflector plane (XY-plane). In general, the radiation pattern of the f_H dipole is strongly affected by the f_L dipole because of twice the length of the f_H dipole, that is, about one wavelength at f_H band. Hence, the amplitude of the current distribution on the f_L dipole is increased and the radiation pattern of the f_H dipole is varied from the desired one. In order to solve this problem, the crank sections having the length of $0.25\lambda_H$ (λ_H : free space wavelength at f_H) are employed in the middle of each side of the f_L dipole.

The principle of the operation of the crank section can be explained from the Fig. 2. The distributions of the current caused by the f_H dipole on each side of the crank sections are out of phase. Moreover, the crank section is assumed to shortened parallel lines having a length of $0.25\lambda_H$. After all, the upper part of the crank section has a short circuit property and the lower part of it has an open circuit property at f_H operation. This condition is equivalent to the one when the dipole is divided into four branches (length of each branch is less than 0.25λ_H) at a point connecting the crank section. Therefore, the amplitude of the undesired current on the f_L dipole can be decreased.

Next, H-plane radiation patterns of the f_H dipole alone, the f_H dipole above the f_L dipole with crank sections and the f_H dipole above the conventional type f_L dipole are shown in Fig. 3, respectively. When the conventional type f_L dipole is used, the radiation pattern of the f_H dipole is deteriorated. However, when the f_L dipole with crank sections having a length of 0.25λ_H are used, the radiation pattern of the f_H dipole does not change from that of the f_H dipole antenna alone.

Figure 4 shows H-plane radiation patterns for f_L operation when the f_L dipole is driven and the f_H dipole is ended by a dummy. The radiation pattern of the dipole with crank sections has good agreement with the one of the conventional dipole. This shows that the dipole with crank sections has the same radiation characteristics as the one without the crank sections.

3. Dual-band array radiation pattern

Figure 5 shows the simulation model of the dual-band array antenna. This array antenna is composed of 7 f_L dipoles with crank sections and 15 f_H dipoles that are located over the infinite reflector plane. All of the f_L dipoles are ended by a dummy and all of the f_H dipoles are driven. The array radiation pattern in f_H operation is shown in Fig. 6. When the conventional f_L dipoles are used, -18dB of grating lobes appear at θ = 30 degrees. On the other hand, when the f_L dipoles with crank sections are used, no grating lobes appear and the array radiation pattern becomes similar to that of the f_H dipoles array without the f_L dipoles. Therefore, it is confirmed that when the dipoles with crank sections are applied as the f_L dipoles for a dual-band array antenna, the grating lobes are effectively suppressed.

4. Conclusion

A new type of dipole with crank sections that can suppress an undesired current has been proposed. The principle of the operation of the crank section has been explained and its effect has been shown by simulation. It has been confirmed that the proposed dipole has the same radiation characteristics as the conventional dipole. The validity of applying the proposed dipole for dual-band array antennas has been indicated. We will evaluate the effect of the proposed dipole experimentally in the near future.

References

[1] Y. Sugimoto and Y. Ebine, "A study on array of base station antenna with 60° and 120° beam-width in horizontal plane for cellular mobile radios," Proceedings of the 1999 IEICE General Conference, B-1-148.

[2] T. Maruyama and K. Kagoshima, "Dual-Frequency Corner-Reflector Antennas Fed by Elements Connected to Parallel Feed Lines," Trans. IEICE, B-II, J77, No. 9, pp. 459-466, Sept. 1994.

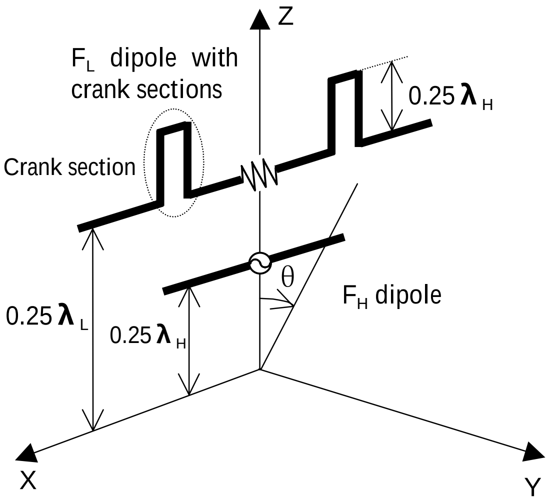

Figure 1. Geometry of a simulation model of the f_H dipole and the f_L dipole with crank sections.

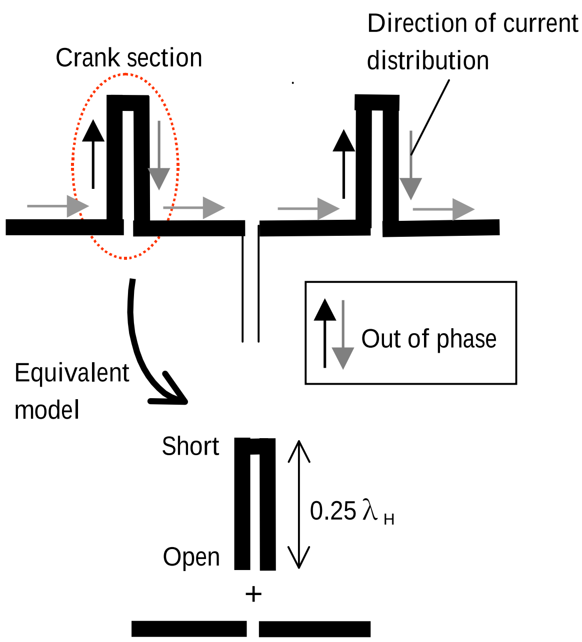

Figure 2. Principle of the operation of the crank section.

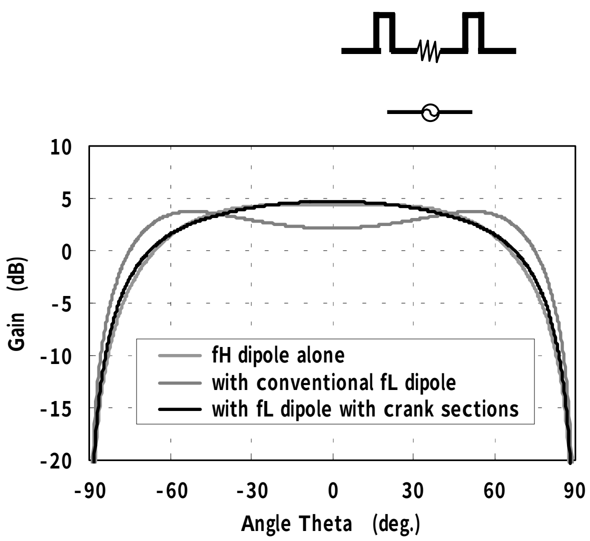

Figure 3. Radiation patterns of the f_H dipole, with the conventional f_L dipole and with the f_L dipole with crank sections.

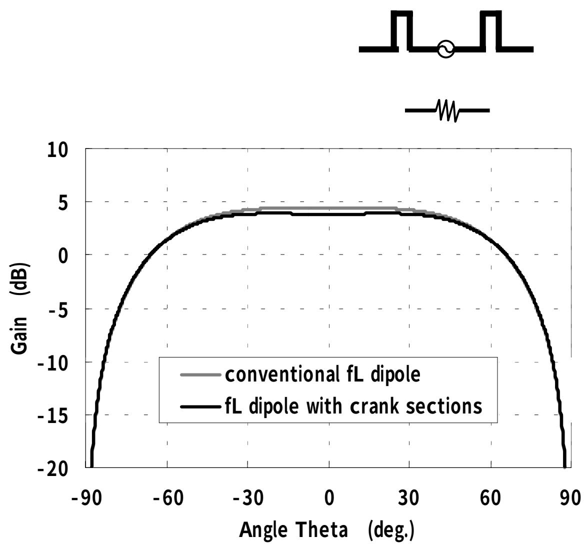

Figure 4. Radiation patterns of the f_L dipole.

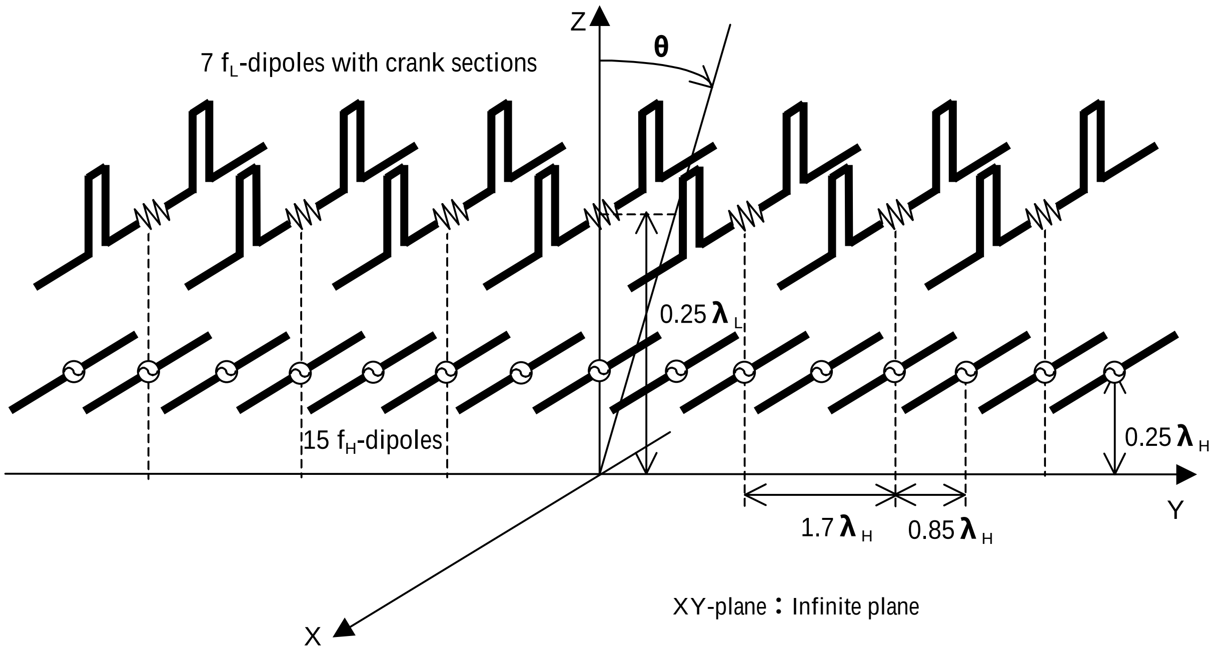

Figure 5. Geometry of a simulation model of the dual band array antenna composed of 7 f_L-dipoles with crank sections and 15 f_H-dipoles.

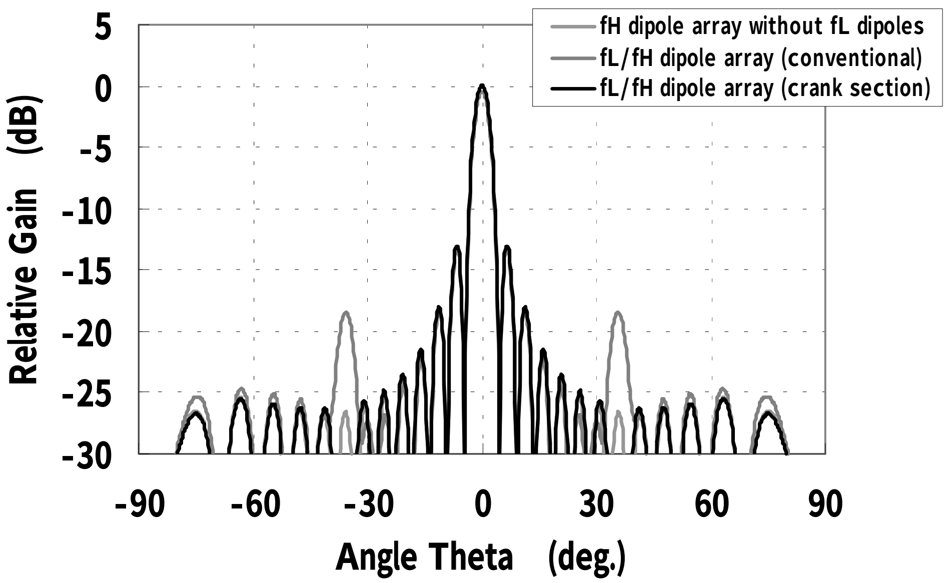

Figure 6. Comparison of radiation patterns among the f_H dipole array, f_H dipole array with the conventional f_L dipole array and with the f_L dipole with crank sections.