

# SYNTHESIS OF A MULTI-RADIAL LINE ANTENNA FOR HIPERLAN

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## ABSTRACT

We present a new antenna concept - the multi-radial travelling wave line antenna - that achieves a broadband conical radiation pattern suitable for use in multiple C-band wireless computer networks.

## 1. INTRODUCTION

Antennas used for wireless communication among computers in WLAN or HIPERLAN networks, which are generally installed on the ceiling of the room housing the computers, should have conical radiation patterns in order to prevent interference due to reflection of the beam from the floor. Conical patterns can be achieved by patch arrays [1], but designs of this kind have relatively narrow bandwidth, which prevents their being used for protocols operating at different frequencies. Here we present a new antenna design concept - the multi-radial travelling wave line antenna - that achieves the necessary conical radiation pattern with broad bandwidth at the expense of a 50% loss of efficiency that is of no account in this kind of application.

## 2. METHOD

We consider an array of  $N$  line sources of length  $L$  that are arranged as the spokes of a wheel at a distance  $h$  from an infinite ground plane lying at  $z = 0$  (Fig.1). Each line is fed at the hub of the wheel and is terminated by a matching load to produce a travelling wave that is assumed to suffer no attenuation. If all the lines are equally excited, then summation of the far-field patterns of the individual lines affords

$$A_{\theta} = \sin(kh \cos\theta) \cos\theta \sum_{n=1}^N \cos(\phi - \phi_n) \frac{\sin X_n}{X_n} e^{-jX_n} \quad (1)$$

$$A_{\phi} = -\sin(kh \cos\theta) \sum_{n=1}^N \sin(\phi - \phi_n) \frac{\sin X_n}{X_n} e^{-jX_n} \quad (2)$$

where

$$X_n = \frac{kL}{2} \left[ 1 - \sin\theta \cos(\phi - \phi_n) \right] \text{ and } \phi_n = \Delta\phi \cdot (n-1) = \frac{2\pi}{N} (n-1) \quad (3)$$

$\Delta\phi = 2\pi/N$  being the angle between successive radial lines (Fig.1) and  $k = 2\pi/\lambda$  the wavenumber.

For given  $N$ , and considering a design frequency  $f_D$  of 5.2 GHz ( $\lambda_D = 5.76$  cm), in this work we used simulated annealing [2] to optimize appropriate parameters (see Results) by minimizing a suitable cost function with respect to  $h$  and  $L$ , which to keep the antenna to a reasonable size were restricted to the regions  $0.05\lambda_D < h < 0.50\lambda_D$  and  $0.50\lambda_D < L < 1.33\lambda_D$ . We then fixed  $h$  and  $L$  at their optimal values and investigated bandwidth with respect to minimum directivity  $D_{min}$  in the coverage zone ( $55^\circ < \theta < 65^\circ$ ), maximum normalized power  $P_{0,max}$  in the region  $0^\circ \leq \theta \leq 10^\circ$ , and  $|E_\theta|/|E_\phi|$ . To this end we established limits for these parameters and then calculated the parameters for each of a sequence of frequencies differing by  $\Delta f = f_D/300$  so as to determine the corresponding values of  $f_U$  and  $f_L$  (respectively the lowest frequency higher than  $f_D$  and the highest frequency lower than  $f_D$  at which the corresponding limit was complied with); bandwidth was then calculated as  $(f_U - f_L)/f_D$ , expressed as a percentage. The parameter limits used were 3 dBi for  $D_{min}$ ; -3 dB for  $P_{0,max}$ ; and 1000 for  $|E_\theta|/|E_\phi|$ .

### 3. RESULTS

In the event, it proved sufficient to maximize directivity  $D$  in the coverage zone by minimizing the cost function  $1/D^2$ , the solutions so obtained being satisfactory as regards all other parameters of interest. For  $N = 10$  the optimal values of  $h$  and  $L$  at the design frequency were  $0.5\lambda_D$  and  $1.0\lambda_D$ , respectively, which afforded  $D_{min}(\lambda_D) = 5.59$  dBi,  $P_{0,max}(\lambda_D) = -55$  dB and  $|E_\theta|/|E_\phi| > 1000$ ; Fig.2 shows the power pattern in the  $\phi = 90^\circ$  plane. Bandwidth was 62% for  $D_{min}$  ( $f_L = 4.32$  GHz,  $f_U = 7.54$  GHz), and infinite for both  $P_{0,max}$  and  $|E_\theta|/|E_\phi|$ .  $P_{0,max}$  never exceeded -20 dB; and for any given value of  $\theta$  in the coverage zone, ripple along the  $\phi$  coordinate never exceeded  $\pm 0.25$  dB.

### 4. FINAL REMARKS

In principle it would be possible to apply the new concept to design an antenna for satellite communications that could be installed on the roof of automobiles and other vehicles, an application in which a conical radiation pattern is likewise desirable [3,4]. In this case, however, it would be necessary to establish progressive phase differences among the individual radial lines in order to achieve circular polarization, which would inevitably limit bandwidth. Further-

more, the 50% loss of power in the matching loads at the ends of the lines would almost certainly be intolerable, whereas in the WLAN or HIPERLAN context it is of no account.

## 5. ACKNOWLEDGEMENTS

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## 6. REFERENCES

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## LEGENDS FOR FIGURES

**FIGURE 1.** Geometry of the proposed antenna.

**FIGURE 2.** Power pattern achieved with  $N = 10$  in the  $\phi = 90^\circ$  plane.

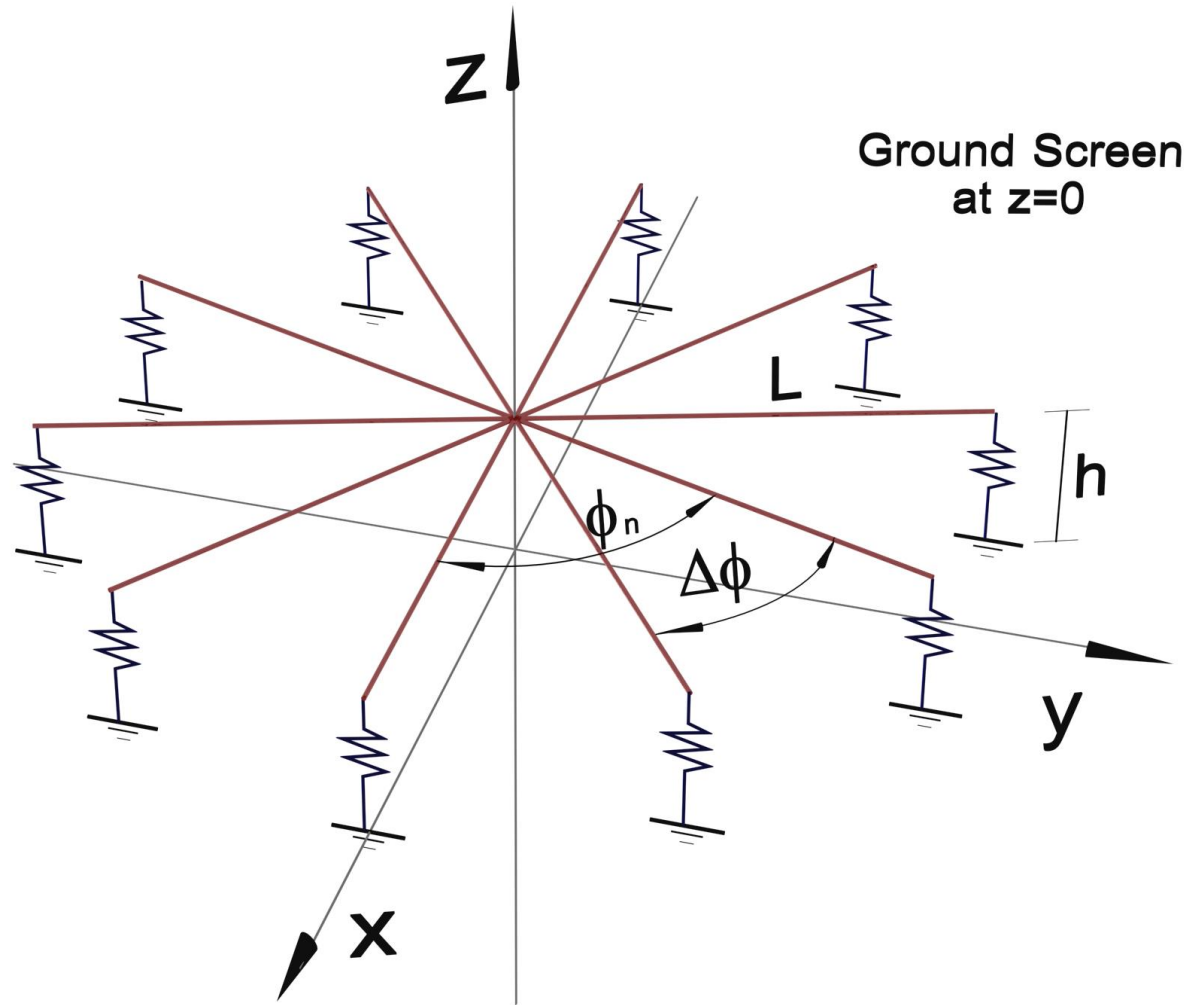


FIG. 1

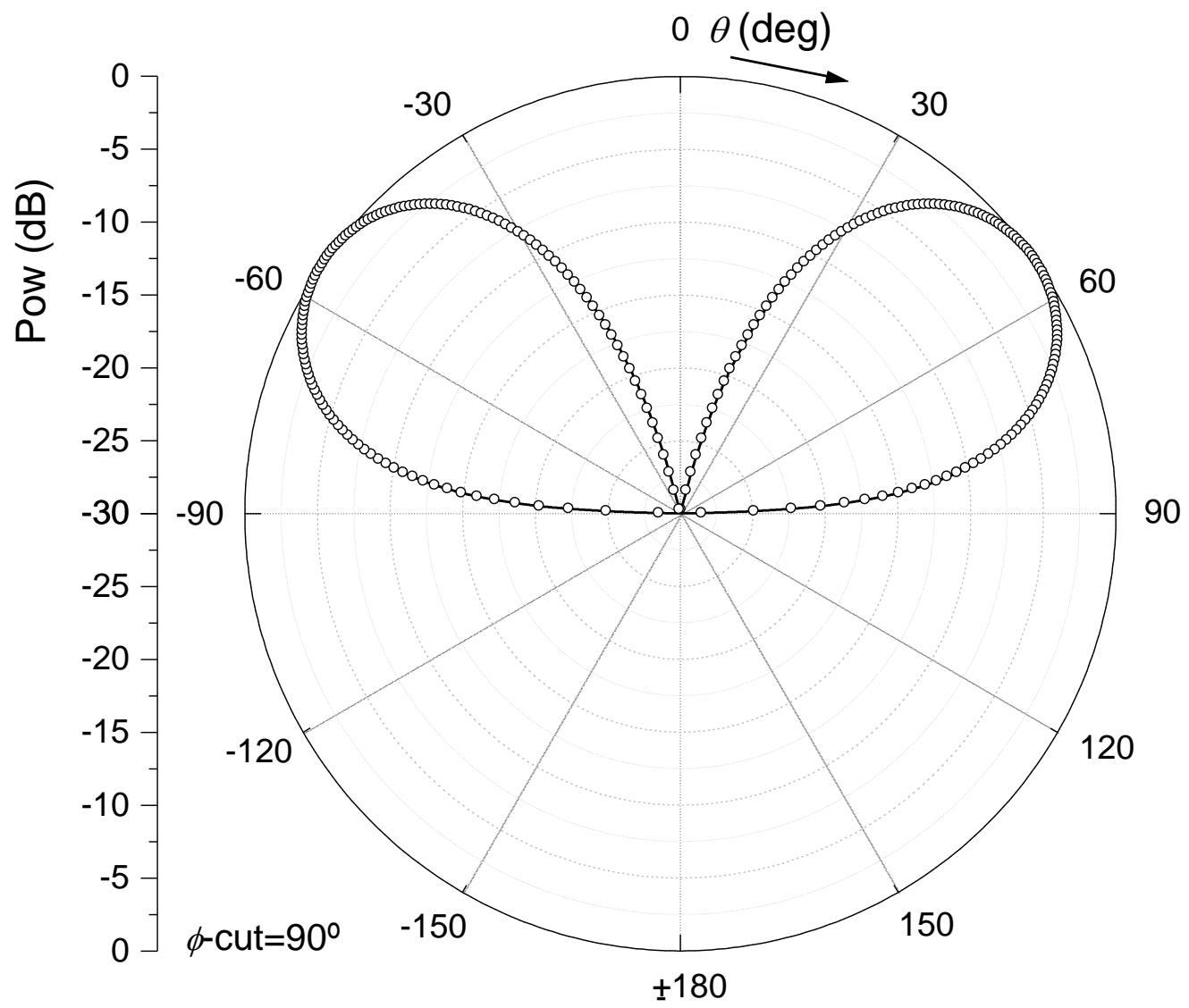


FIG. 2