How Far Is It To Be A Far Field Distance?

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Abstract

A far field test range is a rather convenient and simple means of antenna performance characterization. An essential ingredient for setting up such a test range is the far field distance criterion, the so called Raleigh criterion. It is widely accepted that beyond the Raleigh distance the radiated field behaves as a planewave. This is unfortunately a pitfall in the case of electrically small antennas. Clarification of the true meaning of the far field is therefore inevitable. This involves description of the reality of practical operating condition of the antennas and the nature of the radiation from the antenna.

Keywords: antenna measurement, far field measurement, far field criterion, far field distance

1. Introduction

A far field test range is a test range that simulates the true operational condition of the antenna under test in terms of its incident wave characteristics. In true operational condition the incident wave on the antenna under test is closest in nature to the ideal planewave. It is thus of great importance to produce such an incident wave. Usually the simulation of the ideal planewave is achieved by separating the source antenna of the test range and the antenna under test by a distance far enough to ensure an apparent incident planewave on the antenna under test. This distance can be obtained by simple calculation after the well known far field criterion formula, i.e $\frac{2D^2}{\lambda}$ where D is the largest dimension of the antenna under test and λ the operational wavelength of interest.

It is of interest that most professional engineers and quite a number of those in the academic realm have great faith in the aforementioned far field criterion. Very few really bear in mind that the so called far field criterion arises from certain degree of phase error incurred in the simulated planewave generated in the test range. There is nothing to do with the physical nature of the radiation produced by the source antenna. As a matter of fact the familiar far field criterion is applicable without any concern at all for electrically large antennas. The calculated far field distances in cases of electrically small antennas usually fall within the region called the radiating near field and even worse in a number of cases they are within the reactive near field region where the presence of evanescent wave is observable.

It is therefore worthwhile to clearly state something on the applicability of the far field criterion in order to eradicate misconception concerning the far field criterion. First of all the realistic operating condition of the antenna that leads to the widely accepted use of the planewave for the test and evaluation of antenna performance is to be described. Then the nature of radiation from the antenna is presented. Thus discussion on the applicability of the far field criterion is followed before a few words of conclusion are made to draw the article to a close.

2. Practical operating condition of the antennas

The operating condition of the antenna to be mentioned herein means the distance that separates the transmitting and receiving antennas. In typical operation two antennas are separated with a very large distance such that the distance *R* is much greater than the largest dimension of either antenna *D*, or mathematically $R >> D$. Thus at the receiving end the incident wave will appear relatively planar, or an apparent planewave is detected by the receiving antenna. This can be depicted in Figure 1.

The far field test range is thus designed to have capability of generating an apparent incident planewave rather than a truly planar wavefront to be detected by the antenna under test. This is how the Raleigh criterion is derived. The formula for far field distance is the one on condition that the allowed phase error is $\frac{\pi}{16}$. There is nothing to do with the source antenna radiation characteristics. Therefore one often gets figures of very small number for the far field distance when the test range is to be set up for testing of electrically small antennas. It is thus essential for proper design of the test range that the source antenna radiation characteristics are accounted for. This very nature of the source antenna radiation is to be described in the next section.

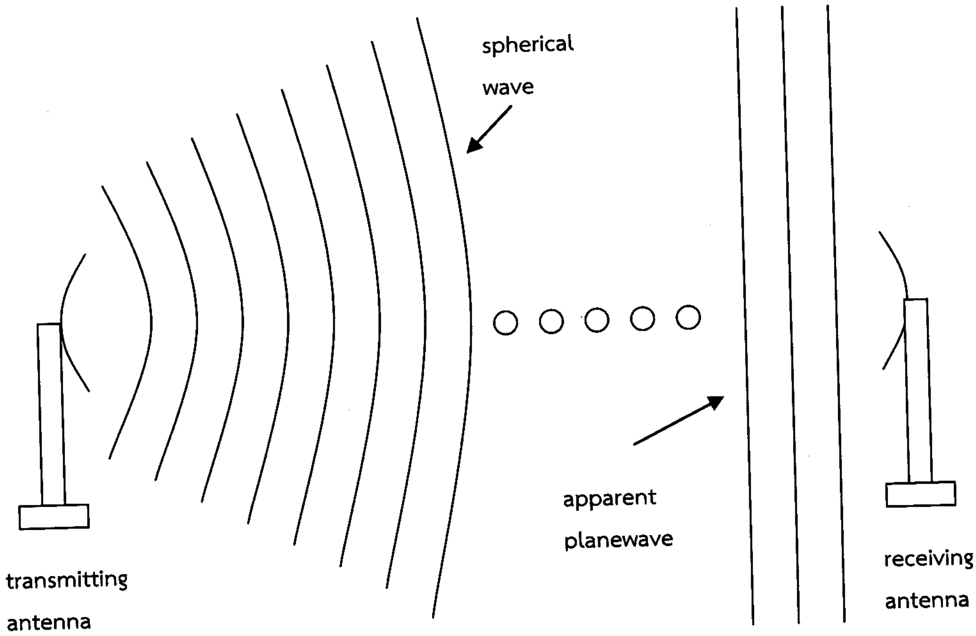

Figure 1 Antennas at work in real world situation.

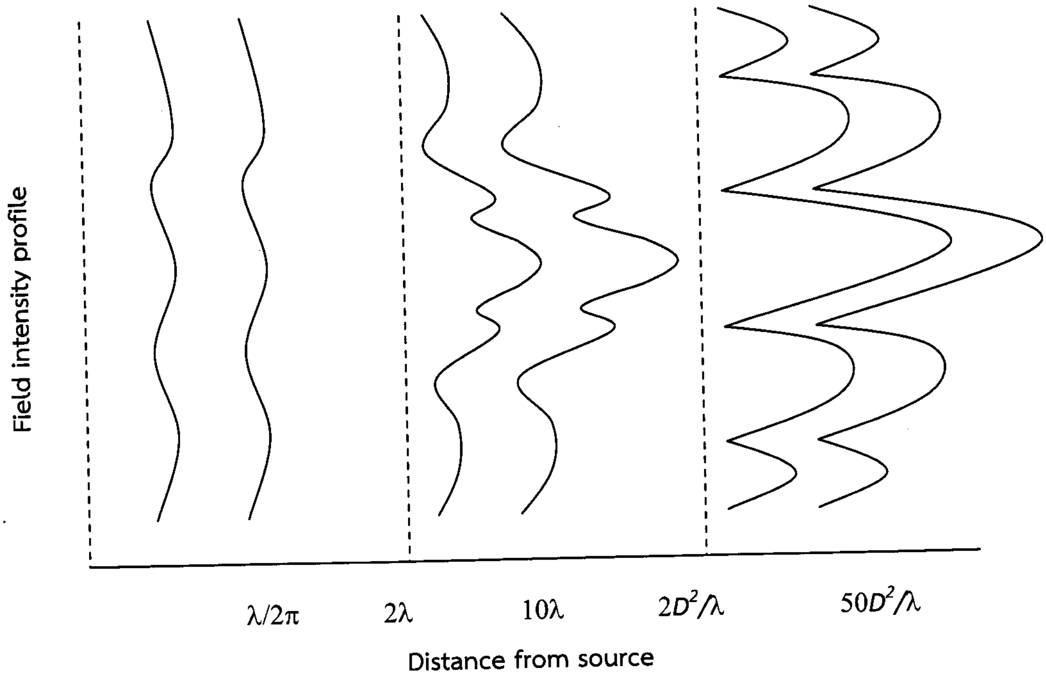

Figure 2 Variation of field intensity profile as the radiation propagates far away from the source.

3. Radiation from an antenna

It is worth mentioning something concerning the variation of the field intensity profile as the radiation from the source antenna propagates far away from the source antenna. Within a distance just a few wavelengths from the source antenna one hardly finds any radiating field. What observable is mostly the oscillatory field component. In this region there is only the presence of the reactive near field. A little further away the oscillatory field component decays a great deal. More of the radiating field is observable. However pattern formation is still immature. Noticeable differences of the field intensity profile can be observed as distance of observation varies. This will improve as the distance from the source antenna gets farther away from about 10 wavelengths from the source antenna. This region is termed the intermediate near field or the radiating near field region.

Beyond the boundary of the radiating near field region begins the far field region wherein pattern formation is complete. No change can be noticed as distance from the source antenna varies. Pattern measurement obtained in this region is the so called far field radiation pattern. The position where the antenna under test is placed has no influence on the measured pattern or whatever parameters of interest. The aforementioned description can be graphically illustrated in Figure 2.

4. Far field proper

It can thus be concluded that the $\frac{2D^2}{\lambda}$ **Raleigh criterion** cannot be adopted straight away. One has to make sure that the calculated distance falls far beyond the reactive near field and also the radiating near field regions. Otherwise the measured parameters of interest would not be qualified as far field parameters. A simple rule of thumb is that if the calculated distance is just a few wavelengths then push it further to a distance of greater than 10 wavelengths.

5. Further readings

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Biography:

Chatchai Waiyapattanakorn obtained his B.Eng and Ph.D from Chulalongkorn University and Queen Mary College, University of London in 1988 and 1994 respectively. He had been with Chulalongkorn University since 1994. He was appointed full professor in 2006. He joined the School of Engineering and Resources, Walailak University in 2008 with the aim of engaging in enhancing higher education performance in the provinces of Thailand. He has numerous technical publications. He is a professorial member of Walailak University Academic Council and at the same time represents the Academic Council in the University Council. In addition he is appointed to the university's human resource management committee. He is in the Academic Promotional Board of Songkla Rajapat University and also an appointed member of the Academic Council of Pathumwan Institute of technology. Outside the academic realm he chairs the national committee on safety standard for household microwave oven.

Research interests: His research interests are antennas and propagation, applied electromagnetics, mathematical and statistical modeling, western literatures and Asian languages and aspects of sustainable developments. He travels extensively and also an active sportsman. His recent interests are in multi-sports such as adventure race and triathlon.