

YAGI-UDA ANTENNA

The Yagi antenna sometimes called the Yagi-Uda RF antenna is widely used where specified gain and directivity are required.

INTRODUCTION

The Yagi-Uda antenna is one of the most successful RF antenna designs for directive antenna applications. This antenna is used in a wide variety of applications where an RF antenna design with gain and directivity is required. It has become particularly popular for television reception, but it is also used in many other domestic and commercial applications where an RF antenna is needed that has gain and directivity.

Not only is the gain of the Yagi-Uda antenna important as it enables better levels of signal to noise ratio to be achieved, but also the directivity can be used to reduce interference levels by focusing the transmitted power on areas where it is needed, or receiving signals best from where the source is present.

HISTORY

The original design and operating principles of this radiator were first described in Japanese in articles published in the Journal of I.E.E. of Japan by S. Uda of the Tohoku Imperial University in Japan [14]. In a later, but more widely circulated and read article [15], one of Professor Uda's colleagues, H. Yagi, described the operation of the same radiator in English. This paper has been considered a classic, and it was reprinted in 1984 in its original form in the Proceedings of the IEEE [15] as part of IEEE's centennial celebration. Despite the fact that Yagi in his English written paper acknowledged the work of Professor Uda on beam radiators at a wavelength of 4.4 m, it became customary throughout the world to refer to this radiator as a Yagi antenna, a generic term in the antenna dictionary. However, in order for the name to reflect more appropriately the contributions of both inventors, it should be called a Yagi-Uda antenna, a name that will be adopted in this book. Although the work of Uda and Yagi was done in the early 1920s and published in the middle 1920s, full acclaim in the United States was not received until 1928 when Yagi visited the United States and presented papers at meetings of the Institute of Radio Engineers (IRE) in New York, Washington, and Hartford.

ANTENNA BASICS

The Yagi antenna design has a dipole as the main radiating or driven element. Further 'parasitic' elements are added which are not directly connected to the driven element. These parasitic elements pick up power from the dipole and re-radiate it. The phase is in such a manner that it affects the properties of the RF antenna as a whole, causing power to be focused in one particular direction and removed from others.

The parasitic elements of the Yagi antenna operate by re-radiating their signals in a slightly different phase to that of the driven element. In this way the signal is reinforced in some directions and cancelled out in others. It is found that the amplitude and phase of the current that is induced in the parasitic elements is dependent upon their length and the spacing between them and the dipole or driven element.



Fig 1: Yagi-Uda antenna showing element types.

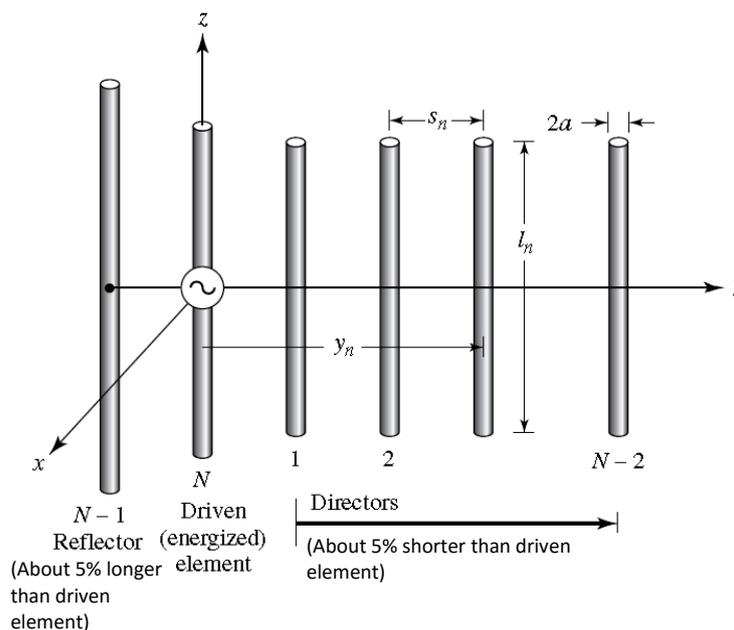


Fig 2: Typical Yagi-Uda antenna configuration.

There are three types of element within a Yagi antenna:

(i) Driven element: The driven element is the Yagi antenna element to which power is applied. It is normally a half wave dipole or often a folded dipole.

(ii) Reflector : The Yagi antenna will generally only have one reflector. This is behind the main driven element, i.e. the side away from the direction of maximum sensitivity. Further reflectors behind the first one add little to the performance. However many designs use reflectors consisting of a reflecting plate, or a series of parallel rods simulating a reflecting plate. This gives a slight improvement in performance, reducing the level of radiation or pick-up from behind the antenna, i.e. in the backwards direction. Typically a reflector will add around 4 or 5 dB of gain in the forward direction.

(iii) Director: The director or directors are placed in front of the driven element, i.e. in the direction of maximum sensitivity. Typically each director will add around 1 dB of gain in the forward direction, although this level reduces as the number of directors increases.

The antenna exhibits a directional pattern consisting of a main forward lobe and a number of spurious side lobes. The main one of these is the reverse lobe caused by radiation in the direction of the reflector. The antenna can be optimized to either reduce this or produce the maximum level of

forward gain. Unfortunately, these two do not coincide exactly, and a compromise on the performance has to be made depending upon the application.

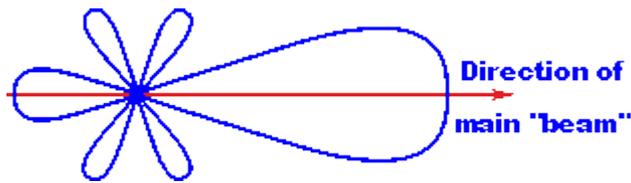


Fig 3: Yagi-Uda antenna radiation pattern.

MERITS AND DEMERITS

The Yagi-Uda antenna offers many advantages for its use in a number of applications:

- It has high gain allowing lower strength signals to be received.
- It has high directivity enabling interference levels to be minimized.
- This antenna allows all constructional elements to be made from rods simplifying construction.
- The construction enables the antenna to be mounted easily on vertical and other poles with standard mechanical fixings.
- The Yagi antenna is particularly useful in applications where an RF antenna design is required to provide required gain and directivity. In this way the optimum transmission and reception conditions can be obtained.

The Yagi antenna also has a number of disadvantages that need to be considered.

- For high gain levels the antenna becomes very long.
- Gain limited to around 20dB or so for a single antenna.