Compact Yagi Antenna for Handheld UHF RFID Reader

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Abstract

This paper describes a compact linearly polarized high gain antenna for a handheld UHF RFID reader. The antenna is a Yagi type structure, with three elements (driver, director, and reflector) which fit into compact footprint (100 mm x 100 mm). The antenna has maximum gain of 6 dBi and VSWR better than 1.3 in approximately 50 MHz band around either European or US RFID bands (865-870 MHz or 902-928 MHz). We describe the antenna structure and present the comparison of simulation results with experimental data.

Introduction

In many practical cases, a maximum tag read range is required and thus high gain antennas (to transmit maximum allowed EIRP) are desired. While antennas for fixed RFID readers can be relatively large [1-2] the antennas for handheld readers must be compact and ergonomically appealing [3]. Making a high gain antenna is always a challenging task, especially if antenna must be compact. Yagi (or, more correctly, Yagi-Uda) type antennas have been known and studied for long time [4-9] but in available RFID literature they so far have been used only for tags [10-13]. In this paper, we describe the design of a Yagi type antenna which can be used as a compact transmit/receive antenna for a handheld UHF RFID reader.

Antenna Design

The requirements posted to this handheld reader antenna were that the antenna must be linearly polarized, work in UHF RFID band (different antenna versions for Europe and US were allowed), be rugged and fit into planar form factor with footprint approximately 100 mm x 100 mm. The form factor was dictated by ergonomic requirements of the handheld reader. Yagi type antenna was a natural choice satisfying these requirements. The general form of the antenna is shown in Figure 1. It consists of director, driver, and reflector elements. All these elements were shaped (see [14] for good example of shaping Yagi antenna elements) to fit into the available footprint while maintaining their resonant frequencies in the desired band. Key parameters in the design are lengths and shapes of antenna elements and their mutual spacing. The number of elements was chosen to be three in order to achieve the desired gain by keeping elements sufficiently spaced apart.

Several antenna versions, with different element shapes and loadings (inductive and/or capacitive, described in more details in [15]), were designed, prototyped, and tested for both US and European (ETSI) UHF RFID bands (902-928 MHz and 865-870 MHz). The electromagnetic modeling and simulation tool which we used for the task of this planar antenna design and optimization was Ansoft Designer [16]. Particular antenna shown in Figure 1 was designed for the European band.

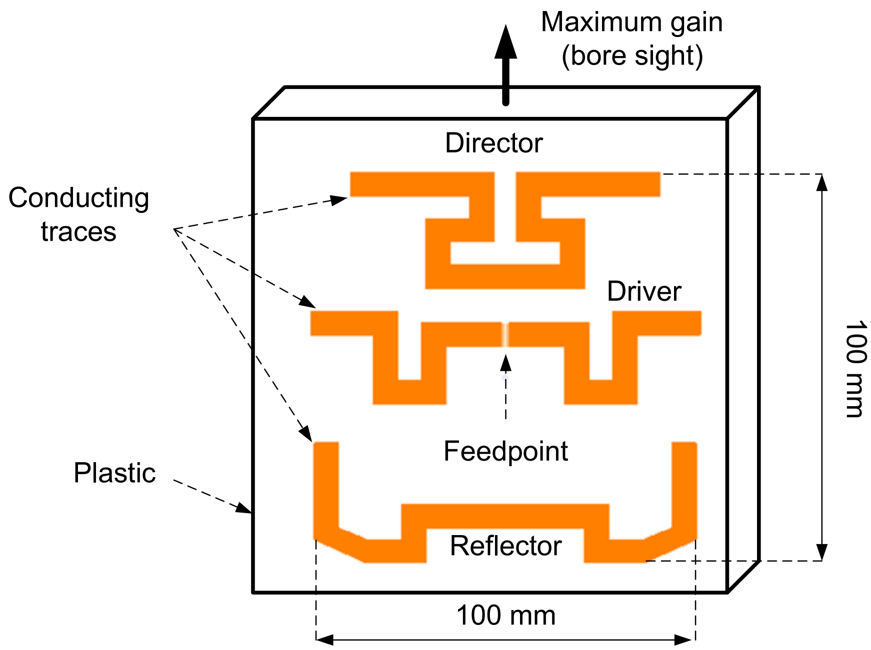

Figure 1. Antenna structure (ETSI version).

To achieve ruggedness, the antenna traces were stamped out of metal and molded into 6 mm thick ABS plastic (dielectric permittivity 3.5) as shown in Figure 2. Antenna impedance was matched to 50 ohm source (RFID reader) using discrete passive matching network implemented on a separate PCB, also molded into plastic. The antenna was attached to handheld RFID reader [17] with four screws. For further compactness and ergonomic appeal, the antenna was slightly bent on edges as can be seen in Figure 2.

Simulated and measured maximum antenna gain and VSWR are given in Figure 3 (for the ETSI version of the antenna attached to the handheld reader without a mobile computer). As one can see from Figure 3, the antenna gain is close to 6 dBi and VSWR is better than 1.3 in wide band (approximately 50 MHz) around the RFID band of interest (865-870 MHz). This was done in order to provide allowance for such effects as antenna detuning and gain degradation due to the presence of operator hand and various mobile computers that can be attached on top of handheld RFID reader. The US version of the antenna had the same general shape as shown in Figure 1 (except slightly different element lengths and different matching network) and exhibited similar performance around US band (902-928 MHz) as antenna shown in Figure 1.

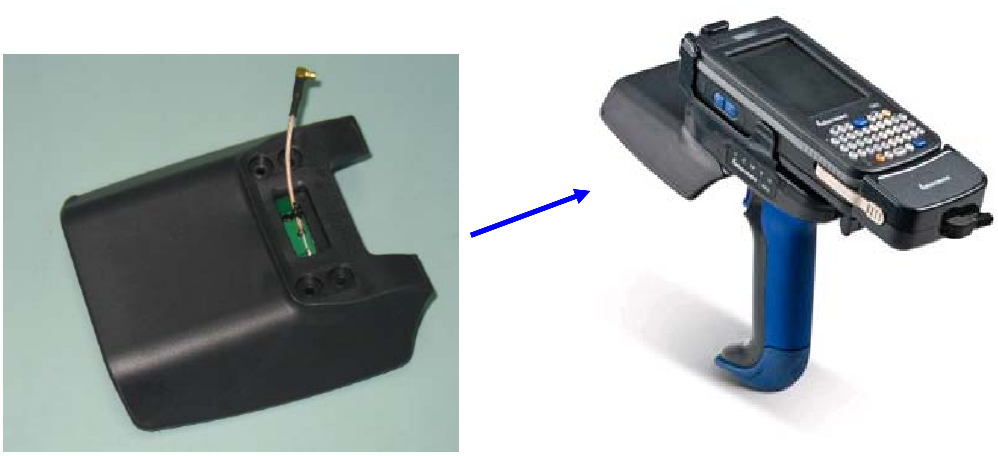

Figure 2. Assembled antenna with matching circuit and coaxial connector: by itself (left) and mounted on handheld RFID reader with mobile computer (right).

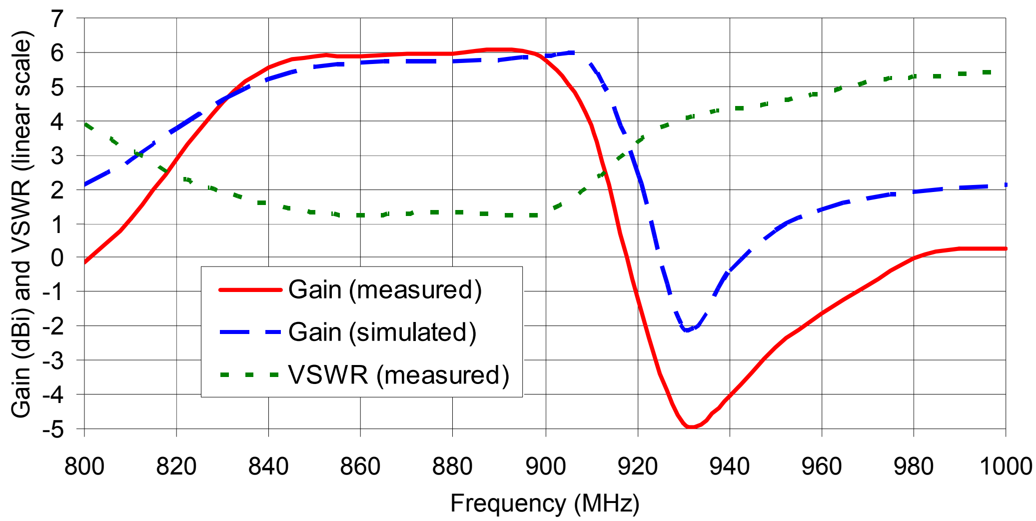

Figure 3. Measured and simulated maximum antenna gain (dBi) and measured VSWR (linear scale) vs. frequency for ETSI version of the antenna.

The handheld with attached antenna was also tested in warehouse environment and successfully read various tags at the same distances as fixed industrial readers with high gain antennas. The handheld reader with the antenna described in this paper was successfully commercialized [17].

Conclusions

In this paper, we described a compact 6 dBi Yagi antenna for UHF RFID reader. Due to its compact form factor and performance characteristics, the described antenna is an attractive solution for handheld reader to maximize tag read range in various production, supply chain, or asset management scenarios, including item-level applications.

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