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# Broadband loaded monopole antenna with a novel on-body matching network

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ABSTRACT

This paper describes the concept and a sample design of a broadband loaded monopole antenna with a novel matching network integrated with the antenna body. The proposed monopole antenna is designed by loading three different lumped loads integrated on a wire antenna and a simple input matching network. Parameters of the matching circuits and the lumped loads optimized by using a genetic algorithm (GA). The proposed antenna loads and the matching network is integrated into the antenna body by the use of printed circuit technology making the antenna fabrication process easy. A prototype of the proposed 1.19-meter monopole antenna is fabricated and measured. The simulation and measurement results show that the proposed antenna operates in the frequency band of 30–600 MHz with VSWR less than 2.5 and the realized gain better than −10 dBi.



## 1. Introduction

Wire antennas are one of the most commonly used antennas since the early days of radio communication, and they still remain one of the best choices for HF and VHF band communication systems. These antennas have the advantages of Omni-directional radiation pattern in the azimuth plane, simple structure and ease of fabrication. They also have drawbacks such as a narrow impedance bandwidth, low efficiency and frequency-dependent radiation pattern in the elevation plane. While in many applications in VHF and HF frequency bands a broadband wire antenna with frequency independent radiation pattern is needed.

In order to overcome the drawbacks of wire antennas different methods has been proposed over the years. One of the effective methods is loading wire antennas with resonant traps, such as circular disk [1], dielectric bead coating [2], RLC circuits [3,4] different types of metamaterials [5,6] and etc. These loads modify the current distribution along the wire antenna and create a broadband multi-resonant frequency response resulting in an almost frequency-independent radiation pattern. Another idea is using a broadband matching network at the antenna feed point to eliminate the imaginary part of the antenna impedance and match the real impedance to 50 Ω [7]. In many recent works a combination of the above mentioned methods are used with the help of appropriate optimization algorithms [8].

In [9], a LR loaded monopole antenna with a matching network consisting of an ideal transformer and shunt inductor was designed for operation over 55–1000 MHz. The antenna has VSWR less than 3.0 and antenna gain greater than 3.2 dBi. In [10] a particle swarm optimization is used in order to design a 30 cm loaded monopole antenna for the frequency band of 150–1000 MHz with VSWR less than 3.5 and antenna gain greater than −5 dBi. However, in both of these works only a prototype wire antenna is fabricated and the loaded antennas and the designed matching network needs a large space in order to be implemented.

The first loaded monopole antenna with the so called an "on-body" matching network is designed in [11] for 30–520 MHz. In this type of loaded monopole antenna, a compact matching network is placed in the antenna pedestal and the antenna pedestal is a part of the antenna impedance transformer. Therefore, this type of loaded monopole can be fabricated and used more conveniently. The fabricated antenna in the mentioned work has 1.47-meter length with VSWR less than 2.0 and gain greater than 0 dBi.

In this paper, a broadband loaded monopole antenna with a novel on body matching network is proposed for 30–600 MHz frequency band. The antenna is composed of three different LR loads and a transformer matching network which are optimized by the genetic algorithm (GA). The matching network is placed at the

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antenna pedestal and fed by coplanar waveguide (CPW) tracks. The antenna loads are also integrated on FR4 printed circuit boards for the ease of antenna fabrication. A prototype of this proposed antenna is fabricated and the measured results are demonstrated and compared with those of simulations.

## 2. Antenna design

The structure of the proposed antenna is shown in Fig. 1 (a). As it can be seen in this figure, the proposed monopole antenna consists of three different on-body loads at three different positions along the wire antenna and a cylindrical pedestal at the bottom of the antenna which contains a matching network.

From the antenna theory, we know that the input impedance of an unloaded monopole antenna has multiple resonances and changes drastically over a broad frequency band. By placing lumped loads along the wire antenna one can reduce the range of these changes but the achieved average input impedance will be around 200 ~ 300 Ω. In such cases, a transformer can be used to improve the matching of loaded monopole antenna.

On the other hand, at very low frequencies the monopole antenna has a small electrical length and the input impedance of the antenna is highly capacitive with a small radiation resistance. Therefore, a parallel inductor can be used in order to compensate for the antenna capacitance at low frequencies. Considering these issues, a transformer in parallel with an inductor is a suitable choice for matching network of the proposed antenna as shown in Fig. 1 (a).

The matching network of the proposed antenna is integrated on a FR4 printed circuit board of 1.6 mm thickness and placed at the antenna pedestal as shown in Fig. 1 (c) and (d). As it can be seen the transformer and shunt inductor is fed by a CPW transmission line which has characteristic impedance of 50 Ω at the connector side and 200 Ω at the wire antenna side. This printed matching network is then connected to the loaded monopole antenna by the use of a long screw. The screw is surrounded by a cylindrical pedestal which acts like a sleeve for it. Therefore, the antenna pedestal can improve the matching of the loaded monopole antenna.

As shown in Fig. 1 (a), three different LR loads are placed along the 1.19-meter monopole antenna. The nearest load to the antenna feeding point is chosen to be a single inductor while at other two positions two parallel LR loads are used. Simulations revealed that loads close to the feeding point have a great impact on the efficiency and VSWR of the antenna. If these loads are chosen to have a resistive part an improved VSWR can be obtained at the cost of degrading the antenna efficiency. Therefore, unlike the previous

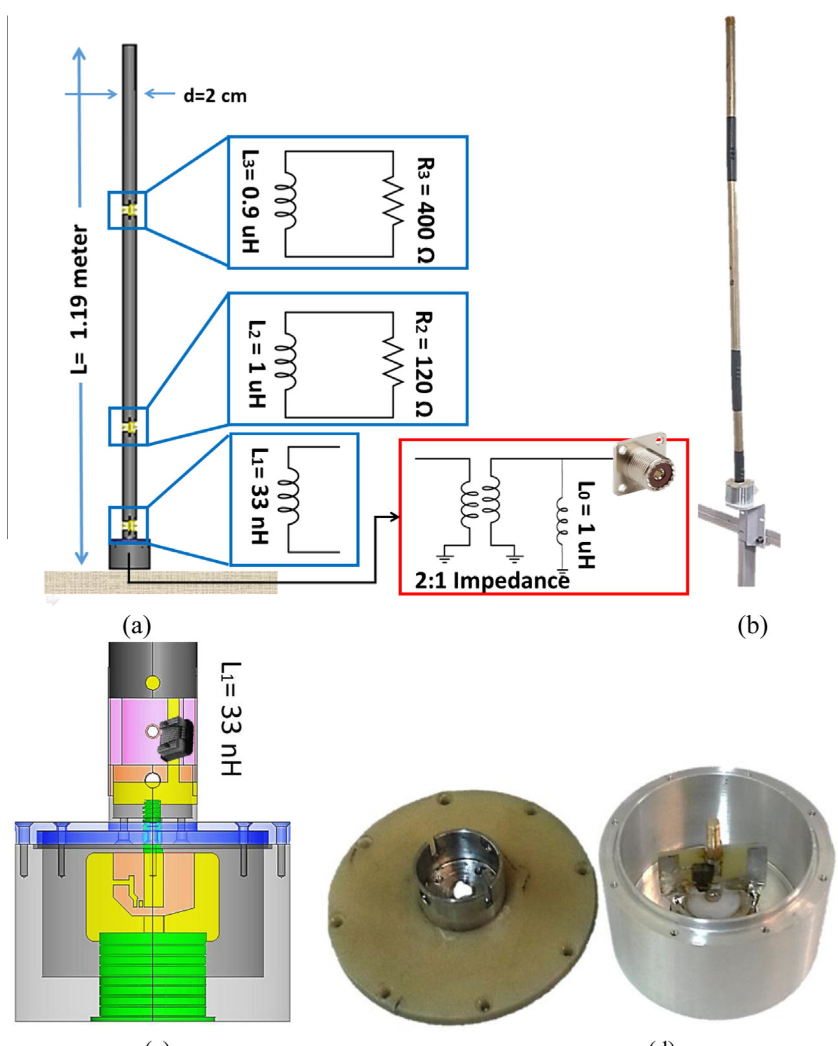


**Fig. 1.** the proposed broad band loaded monopole antenna with a novel matching network, (a) The simulation view of the proposed antenna, (b) a fabricated prototype of the proposed antenna, (c) matching network view and (d) Matching network view of the fabricated prototype.

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